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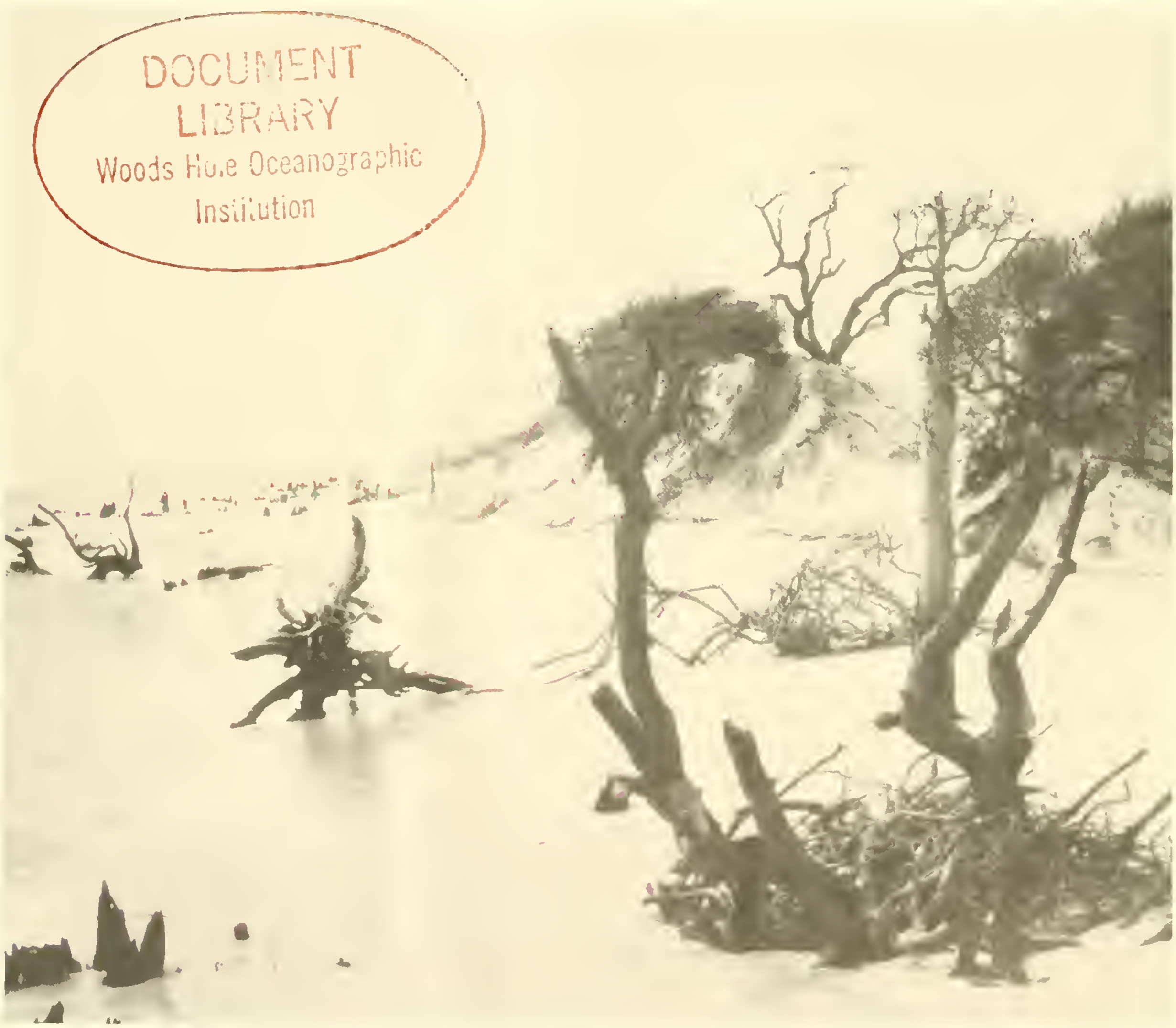
Ecological Characterization Atlas of Coastal Alabama: Map Narrative



Fish and Wildlife Service

Minerals Management Service

U.S. Department of the Interior

FWS/OBS-82/46
MMS 84-0052
August 1984

ECOLOGICAL CHARACTERIZATION ATLAS OF COASTAL ALABAMA: MAP NARRATIVE

by

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PREFACE

The purpose of the Alabama coastal ecological characterization atlas study is to provide information concerning the biological, physical, and social conditions in coastal Alabama, specifically, Mobile and Baldwin Counties, Alabama. The atlas consists of composite overlay topic information provided on 1:100,000-scale base maps. There are six base maps with five main subject maps, making a total of thirty maps. A narrative accompanying the maps discusses the mapped topics. This study is one of a series of characterizations of coastal ecosystems produced by the U.S. Fish and Wildlife Service to provide coastal planning and management personnel with information relative to coastal ecology.

Information on endangered and threatened species in the Biological Resources section has been updated to reflect their Federal status as of June 1985.

This project was conducted under Contract FWS 14-16-0009-81-062. Funding was provided by the Bureau of Land Management (Minerals Management Service) and the U.S. Fish and Wildlife Service.

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SUMMARY

The southwest Alabama coastal region is the study area of this narrative and accompanying maps. The offshore area includes the region from the State-Federal demarcation to the shoreline, and the inland area includes Mobile and Baldwin Counties.

These counties are included in the following six U.S. Geological Survey 1:100,000-scale topographic maps:

Citronelle	Bay Minette
Atmore	Biloxi
Mobile	Pensacola

The data in this atlas meet all cartographic and narrative specifications of the Minerals Management Service and the U.S. Fish and Wildlife Service and should be useful for coastal decisionmakers.

The topics included within this map narrative are biological resources; socioeconomic features; soils and landforms; oil, gas, and mineral resources; and hydrology and climatology.

CONVERSION TABLE

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
kilometers (km)	0.6214	miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees	1.8(°C) + 32	Fahrenheit degrees

U.S. Customary to Metric

Multiply	By	To Obtain
inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
acres	0.4047	hectares
square miles (mi^2)	2.590	square kilometers
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees	0.5556(°F - 32)	Celsius degrees

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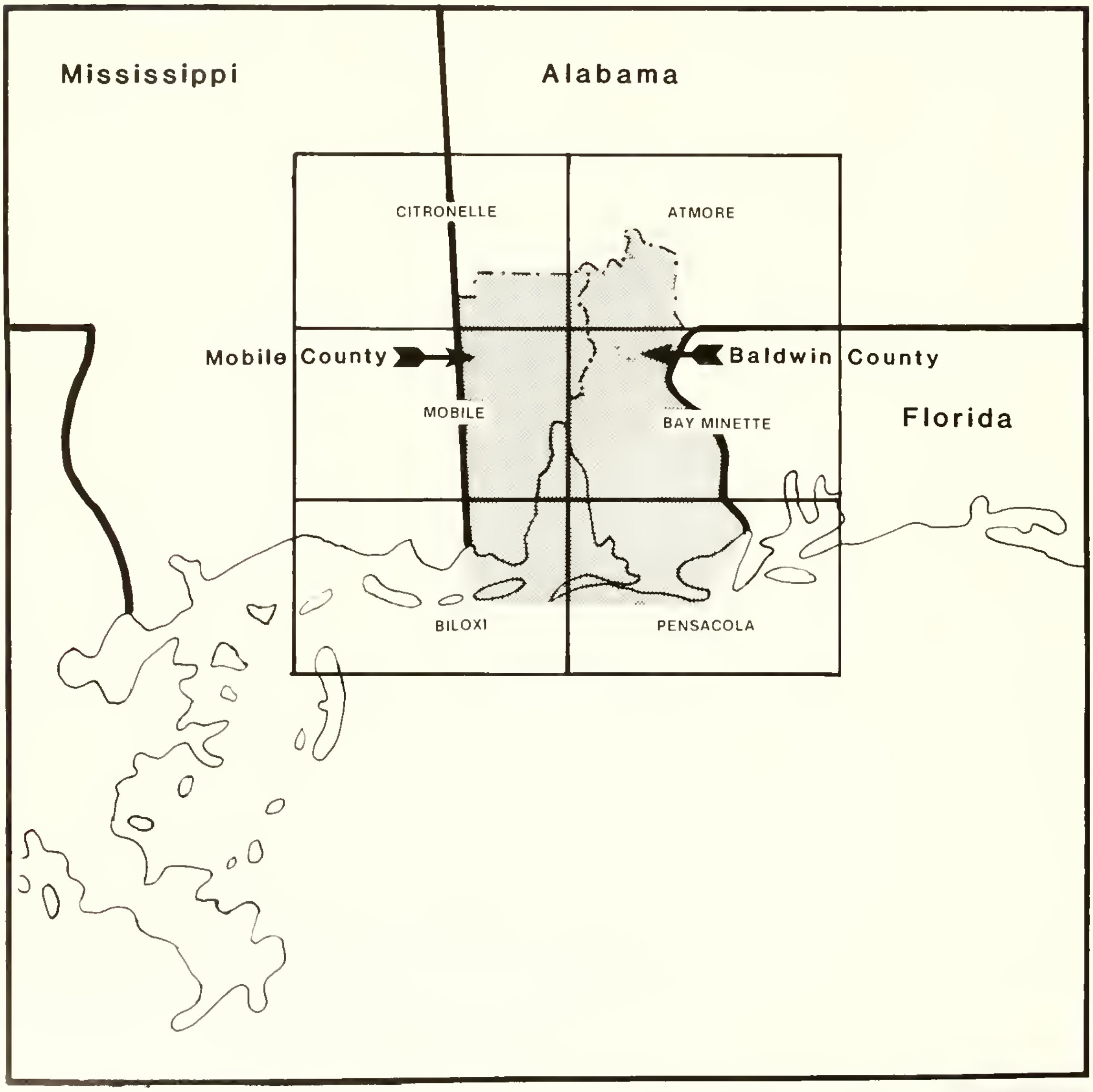

COASTAL ALABAMA ECOLOGICAL ATLAS PROJECT AREA

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Alabama Historic Commission

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Hess Pipeline Company

Shell Oil Company

Marion Pipeline Company, Inc.

United Gas Pipeline Company

Union Oil Company of California

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BIOLOGICAL RESOURCES

INTRODUCTION

Coastal Alabama has a great diversity of habitats within its boundaries. These habitats support many different species of plants and animals, in some instances large populations. Included are a majority of the terrestrial and freshwater species characteristic of temperate Eastern United States along with subtropical species found in the lower Coastal Plain. A great variety of salt and brackish water animals and plants is also found in the state's coastal waters

Diverse habitats meet and blend in this coastal area, producing a richness of plant and animal life seldom found in inland areas. Man has been utilizing the biological resources of coastal Alabama for thousands of years and will continue to utilize them in the future, preferably with wise management practices.

WETLAND HABITATS

In coastal Alabama wetlands habitats are located essential nesting, breeding, rearing, nursery, and feeding grounds for many species of fish, birds, and other wildlife. Wetlands provide habitats for unique floral and faunal communities, many of which include endangered or threatened species. Wetlands are also important in improving water quality by recycling nutrients and removing toxic materials from the environment. They provide erosion control and reduce turbidity as well as providing water storage areas.

Increasing recognition of the value of wetlands has led to a need for more information on how these systems operate and how they are affected by human activities and naturally occurring changes in the environment. To provide a system suitable for gathering scientific information on a nationwide basis, the U.S. Fish and Wildlife Service is conducting a National Wetlands Inventory based on a standardized classification system. The following description is from Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979) and describes the concepts and definitions utilized in the National Wetlands Inventory classification system.

Only in recent years has the concept of "wetland" unified the older classifications of swamp, marsh, bog, etc. Wetlands are generally lands where the dominant factor determining the nature of soil development and the types of plants and animals inhabiting the area is saturation with water. The substrate or soil is at least periodically saturated with or covered by

water. Plants and animals not physiologically adapted to a water-saturated environment are severely stressed in wetland habitats, and consequently do not compete well with more water-tolerant species.

Wetlands, as defined by the U.S. Fish and Wildlife Service, either: (1) support predominantly wetland vegetation (hydrophytes) at least periodically; and/or (2) have a substrate of primarily undrained, periodically anaerobic (hydric) soil; and/or (3) have a nonsoil (bedrock, gravel, peat, etc.) substrate saturated with or covered by water during at least some of the growing season each year. The upper limit of a wetland is delineated by the border between predominantly hydrophytic (very wet) and mesophytic (average moisture) or xerophytic (arid) plant cover, the transition between hydric and nonhydric soils, and, in areas without plant cover or soil, the upper limit of land which is covered by or saturated with water at some time each year.

The lower limit of wetlands in saltwater (marine and estuarine) systems is defined as the elevation of the extreme low water of spring tide. In freshwater systems such as rivers (riverine), lakes (lacustrine), and nontidal marshes (palustrine), the lower limit is defined as the depth to which emergents grow or 2 m (6.6 ft) whichever is deeper.

For this coastal Alabama study, three categories of wetlands are mapped: estuarine intertidal emergent wetland, palustrine emergent wetlands, and the combination of palustrine forested and palustrine scrub-shrub wetland.

Estuaries are defined as either deepwater or adjacent tidal wetlands that have some access to the open ocean, although the saltwater is at least occasionally diluted by freshwater runoff from land. Some estuaries actually have higher salinities than the open ocean due to evaporation in enclosed bays, but most have lower salinities. Estuaries are considered to extend upstream to the point where ocean-derived salts measure less than 0.5 part per thousand (ppt) during average annual low flow. The seaward border of an estuary may be the limit of seawater continuously diluted by freshwater runoff, the seaward limit of wetland plants, or an imaginary line closing a river, bay, or sound. Estuarine systems are divided into the subtidal subsystem, which is continuously submerged, and the intertidal subsystem, which is alternately exposed and submerged by tidal changes, and its associated splash zone.

Palustrine areas include tidal areas with ocean-derived salinities of less than 0.5 ppt during average annual low flow and nontidal wetlands that are dominated by trees, shrubs, persistent emergent vegetation, or emergent mosses or lichens. Wetlands lacking such vegetation are designated palustrine if they have an ocean-derived salinity of less than 0.5 ppt, have an area of less than 8 ha (20 acres), lack active wave-formed or bedrock shoreline features, and are less than 2 m (6.6 ft) deep at low water. The palustrine classification includes areas traditionally called swamp, marsh, fen, bog, and prairie.

The dominant plant cover in emergent wetlands, whether estuarine or palustrine, is erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is mostly perennial and is present for most of the

growing season in most years. Emergent plant cover is subdivided into persistent and nonpersistent categories. Persistent emergents remain standing until at least the beginning of the next growing season. Nonpersistent emergents fall to the surface of the substrate at the end of the growing season and there is no obvious sign of vegetation during part of the year.

Woody vegetation taller than 6 m (20 ft) is defined as forest. and shorter than 6 m as scrub-shrub. Scrub-shrub includes young trees. true shrubs, or trees and shrubs that have been stunted due to adverse environmental conditions. Both forest and scrub-shrub classes are divided into five subclasses: broad-leaved deciduous, needle-leaved deciduous. broad-leaved evergreen, needle-leaved evergreen, and dead plants.

Palustrine forested and scrub-shrub areas are separated on the basis of the percent covered by the uppermost life form (i.e., forest). Thirty percent coverage is considered the "threshold" for designation. In other words, if an area has 40% forest canopy over 70% scrub-shrub understory, the area is designated forest. If there were 20% forest over the same 70% scrub-shrub understory, the area would be designated scrub-shrub. If forest and scrub-shrub are less than 30% alone, but together comprise 30% or more, the area is designated scrub-shrub. Palustrine and scrub-shrub areas are mapped together as a single unit for the purpose of this study.

The areal wetland data for the 1:100,000-scale maps provided in the Atlas were derived from analysis of the 1:24,000 National Wetlands Inventory maps. Acreages for each wetland category were calculated from the 1:100,000-scale atlas maps using a dot grid, which is a statistical area measurement technique. In Mobile and Baldwin Counties the total wetland acreage was calculated to be approximately 692,000 acres, or about 38% of the two counties total area. Of the three categories mapped, palustrine forest and scrub-shrub was predominant with 621,000 acres in this category, or about 34% of the area mapped. Estuarine emergents totaled 61,000 acres and palustrine emergents only 10,000 acres. Thus, these two categories together were less than 4% of the total acreage of Mobile and Baldwin Counties.

BIRD RESOURCES

Seabirds and Wading Birds in Coastal Alabama

The mapped locations of nesting sites for gulls, terns, and wading birds are from Johnson (1979), Portnoy (1977), O'Neil and Mettee (1982), and the U.S. Army Corps of Engineers (1983). The most important coastal bird nesting areas occur in Mississippi Sound and southwestern and southeastern or lower Mobile Bay (Figure 1 and Table 1). Nesting sites tend to change over time; thus, those listed and mapped should be considered as only a general guide.

The most important nesting site is Cat Island (Biloxi quadrangle), which in recent years has supported colonies of the following wading birds: cattle egret (*Bubulcus ibis*), great egret (*Casmerodius albus*), snowy egret (*Egretta thula*), reddish egret (*Egretta rufescens*), green-backed heron (*Butorides striatus*), tricolored heron (*Egretta tricolor*), little blue heron (*Egretta caerulea*), glossy (*Plegadis falcinellus*) and/or white-faced (*P. chihi*) ibis,

and white ibis (Eudocimus albus). The reddish egret has been recorded once as having nested on Cat Island, but the evidence is not conclusive (Imhof 1976). Among the seabirds, the least tern (Sterna antillarum) also nests on Cat Island in sandy areas. Because of habitat loss throughout the U.S., this species is considered threatened in Florida (Kale 1978), and it should probably be considered a "species of special concern" elsewhere according to a personal communication from Alexander Sprunt IV, National Audubon Society, Tavernier, FL.

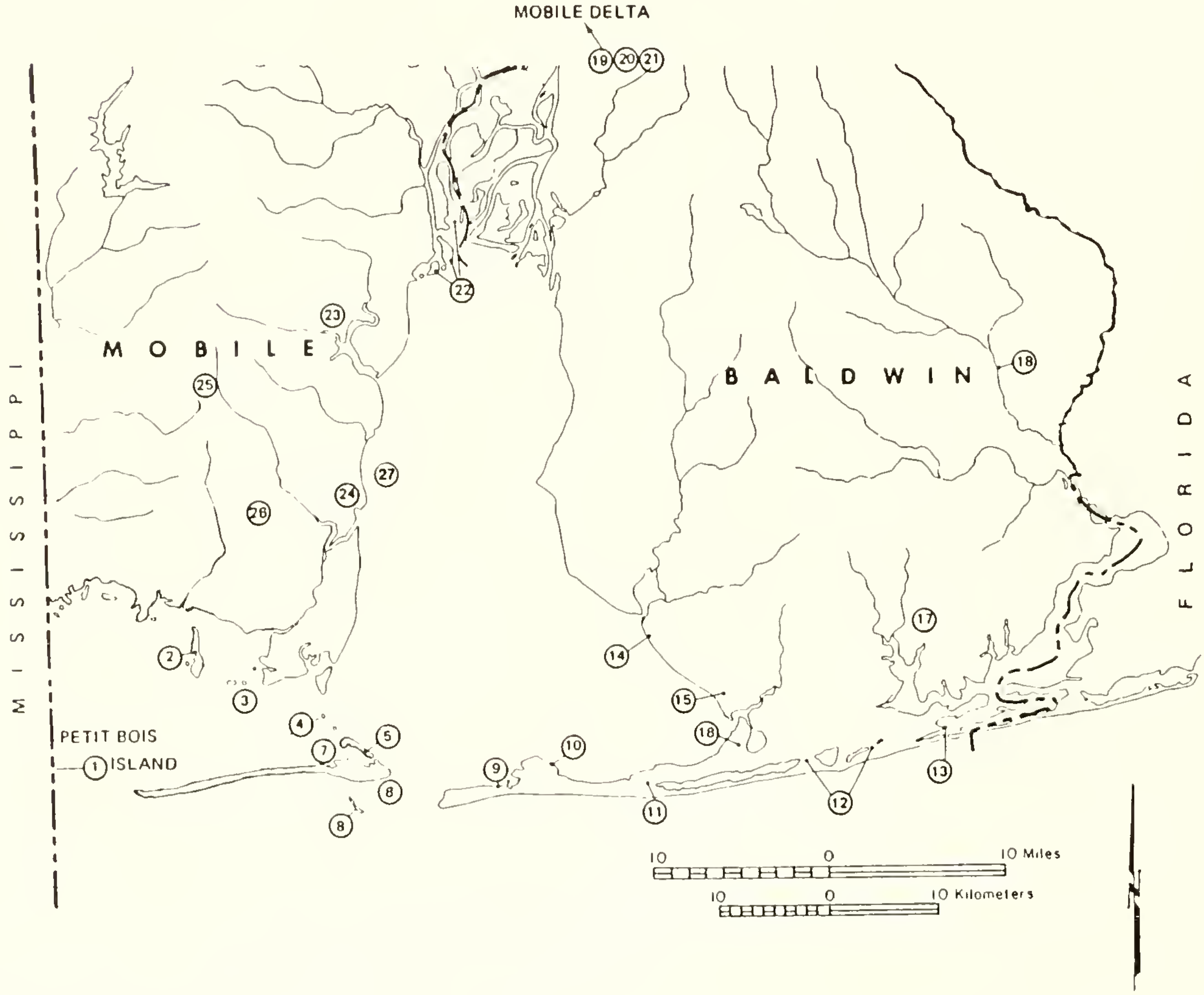

Figure 1. Distribution of wading bird nesting colonies in coastal Alabama (Johnson 1979; O'Neil and Mettee 1982).

Table 1. Wading bird nesting colonies identified for coastal Alabama, species present, and their present status (Johnson 1979; O'Neil and Mettee 1982; U.S. Army Corps of Engineers 1983).

Colony[a] number	Colony location	Species present[b]	Present[c] status
1	Petit Bois Island	CE,GE,TH	NA
2	Isle Aux herbes	TH	NA
3	Cat Island	CE,GE,SE,RE,GH,TH LB,WG,GI,WI,WFI,GI	A
4	Grant's Isle	TH,SE	NA
5	Pass Drury	LB,GH	A
6	Dauphin Island Audubon Sanctuary	GB,LB,GH	A
7	Salt Creek	GH,BC	NA
8	Sand Island	Colonial Seabirds	A
9	Navy Cove	GB	A
10	Little Point Clear	GB	A
11	Little Alligator Lake	GB	A (UK 1983)
12	Gulf Shores-- Orange Beach	GB	NA
13	Walker Island	GB	A
14	Weeks Bay	SE,TH,LB	NA
15	Bon Secour River	CE	NA
16	Oyster Bay	TH,LB	NA
17	Miflin Creek	LB,CE	NA
18	Gatewood Colony	CE,LB,WI	A
19	Southfield and Mims Lake	WI,GE,LB,YC	A
20	Miflin Lake	GH,LB	A
21	Negro Lake	GH,LB,WI,CE,YC	A
22	Blakeley Island	Colonial Shore birds	A
23	Dog River	GH,LB,CE	UK
24	East Fowl River	GH,LB	UK
25	Theodore-Dawes Road	LB	A
26	Deakle's Farm	CE	NA
27	Theodore Disposal Island (Hollinger's Island)	Colonial seabirds,BP	A

[a]Colony numbers used in Figure 1.
[b]Species abbreviations: GB (Great Blue Heron), LB (Little Blue Heron), TH (Tricolored Heron), GH (Green-backed Heron), SE (Snowy Egret), CE (Cattle Egret), GE (Great Egret), RE (Reddish Egret), GI (Glossy Ibis), WFI (White-faced Ibis), WI (White Ibis), YC (Yellow-crowned Night-Heron), BC (Black-crowned Night-Heron), BP (Brown Pelican).
[c]Colony status abbreviations: A (Active), NA (Not Active), and UK (Unknown).

Grant's Island (Biloxi quadrangle) was a nesting site for two wading birds, the tricolored heron and the snowy egret, but the island was destroyed by Hurricane Fredric. The Dauphin Island Audubon Sanctuary (Biloxi quadrangle) is a nesting site for great blue heron (Ardea herodias), little blue heron, and green-backed heron. Also on Dauphin Island, the Salt Creek area is a nesting site for green-backed heron and black-crowned night-heron (Nycticorax nycticorax) (U.S. Army Corps of Engineers 1983).

In addition to the nesting colonies mentioned above, the beaches and dunes of coastal Alabama are utilized by various seabirds as scattered nesting sites. Dauphin Island beaches provide sites for nesting least tern, and in at least one area, for common tern (Sterna hirundo), gull-billed tern (Sterna nilotica), and black skimmer (Rynchops niger). Sand Island (Biloxi quadrangle) is also a nesting site for these four species as well as royal tern (Sterna maxima) and sandwich tern (S. sandvicensis). The locations of seabirds nesting sites vary, and the changes in shape and size of the sandy islands with time also affect nesting. The Theodore Disposal Island (Mobile and Biloxi quadrangles) provides nesting sites for black skimmers, least terns, gull-billed terns, royal terns, the brown pelican (Pelecanus occidentalis), Caspian terns (Sterna caspia), common terns (S. hirundo), and laughing gulls (Larus atricilla).

In the Bon Secour Bay area, wading birds nest sporadically in taller trees. Great blue herons nest at Navy Cove, Little Alligator Lake, and Little Point Clear (Pensacola quadrangle). The present status (1983) of the Oyster Bay site (Pensacola quadrangle), which was used by tricolored and little blue herons, is inactive. Also inactive is the Bon Secour River site (Pensacola quadrangle), utilized in the past by cattle egret. The Weeks Bay site (Pensacola quadrangle), used in the past by snowy egret, tricolored heron and little blue heron, is inactive. In the Perdido Bay area (Pensacola quadrangle), great blue heron nesting has been reported at Gulf State Park (Pensacola quadrangle), Walker Island, and Cotton Bayou. Only the Walker Island site (Pensacola quadrangle) remains in active use (O'Neil and Mettee 1982; U.S. Army Corps of Engineers 1983).

In the Mobile Delta area north of the causeway are scattered wading bird nesting sites. The largest reported colony at Negro Lake (Bay Minette quadrangle) was for nesting green-backed heron, little blue heron, white ibis, cattle egret, and yellow-crowned night-heron (Nycticorax violacea). In the upper delta there are two other active nesting sites. Mims Lake (Bay Minette quadrangle) has an active colony of white ibis, great egret, little blue heron, and yellow-crowned night-heron. Miflin Lake (Bay Minette quadrangle) has active colonies of green-backed heron and little blue heron (Johnson 1979, U.S. Army Corps of Engineers 1983).

Shorebirds in Coastal Alabama

Various shorebirds use sandy beach areas, sand dunes, and adjacent salt marshes in coastal Alabama. Some are seasonal visitors, while others are year-round residents. Shorebirds that migrate but do not nest in coastal Alabama include such species as semipalmated plover (Charadrius semipalmatus), black-bellied plover (Pluvialis squatarola), whimbrel

(Numenius phaeopus), short-billed dowitcher (Limnodromus griseus) and sanderling (Calidris alba) (Imhof 1976). In addition, many other species pass through the area during migration or overwinter there.

Shorebirds that nest in Alabama and may be considered permanent residents include willet (Catoptrophorus semipalmatus), American oystercatcher (Haematopus palliatus), snowy plover (Charadrius alexandrinus), Wilson's plover (Charadrius wilsonia), black-necked stilt (Himantopus mexicanus), clapper rail (Rallus longirostris), and king rail (Rallus elegans) (Imhof 1976). Specific nesting sites of these species are variable and generally not reported in the literature. However, some nesting sites occur on Daupnin Island, in the Bon Secour Bay area, on Blakeley Island, the Pinto Pass area, around Lake Shelby, and many other areas.

Probably the most common marsh bird found along the coast is the clapper rail, usually found in saline and brackish marsh areas. They are abundant, and also breed in the marshes and on the islands of Mississippi Sound. The greatest densities are found on Marsh Island (Biloxi quadrangle) and along Heron Bay (Holliman 1978). Snowy plover are reported to nest on Sand Island (Biloxi quadrangle), west end of Dauphin Island (Biloxi quadrangle), and Fort Morgan peninsula (Pensacola quadrangle); and the black-necked stilt on the dredge spoil areas of Blakeley, Pinto, and McDuffie Islands (Mobile quadrangle) (Johnson 1979). Theodore Disposal Island (Hollingers Island) (Mobile and Biloxi quadrangles) is also reported as a nesting site for the brown pelican (P. O'Neil 1984, pers. comm.). Additionally, over 600 white pelicans were observed on the Theodore Disposal Island (D. Cooley, U.S. Fish and Wildlife Service; pers. comm. 1984).

Information on certain bird species believed to be threatened or endangered, such as osprey and the peregrine falcon, is contained in the section on threatened and endangered species.

Waterfowl Concentration Areas in Coastal Alabama

The U.S. Fish and Wildlife Service administers the Migratory Bird Habitat Preservation Program, which is designed to preserve critical waterfowl habitat by acquisition from private owners (Fish and Wildlife Service 1982). This program of purchases from willing owners is designed to save from development areas vital to waterfowl species. Under this program, specific areas in the United States have been identified as key wetland units, most important to nesting or migrating waterfowl. Two units have been identified in coastal Alabama, the Point Aux Chenes-Grand Bay Swamp Unit (Biloxi quadrangle) and the Lower Mobile Delta Unit (Mobile and Bay Minette quadrangles). The Lower Mobile Delta Unit is by far the most important as indicated by the acreage versus wintering population totals shown in Table 2.

The most numerous waterfowl species in the Lower Mobile Delta are lesser scaup (Aythya affinis), gadwall (Anas strepera), redhead (Aythya americana), northern pintail (Anas acuta), green-winged teal (A. crecca), blue-winged teal (A. discors), mallard (A. platyrhynchos) and american wigeon (A. americana). Wood duck (Aix sponsa) and hooded mergansers (Lophodytes cucullatus) are found in the thicker wooded areas and are two of the few duck

Table 2. Average annual waterfowl population by species 1969-78 (modified from Fish and Wildlife Service 1982).

Species	Point Aux Chenes-Grand Bay Swamp Unit (31,649 acres)	Lower Mobile Delta Unit (21,507 acres)
Mallard	100	400
American Black Duck	---	128
Mottled Duck	25	50
Gadwall	50	1,622
American Wigeon	100	511
Green-winged Teal	25	800
Blue-winged Teal	10	200
Northern Shoveler	---	33
Northern Pintail	25	978
Wood Duck	50	250
Redhead	300	1,422
Canvasback	---	722
Lesser Scaup	250	4,444
Ring-necked Duck	---	289
Common Goldeneye	---	11
Bufflehead	---	11
Ruddy Duck	---	56
American Coot	100	16,544
TOTAL	1,035	24,471

species nesting in coastal Alabama. Mottled duck (Anas fulvigula) are also known to breed on Dauphin Island (Imhof 1976). American coot (Fulica americana), although not a duck, is the most numerous waterfowl species in the Mobile Delta area, composing almost 68% of total waterfowl population. Other areas in which large populations of certain waterfowl species are sometimes found during the winter are upper Perdido Bay, around Dauphin Island and in Bon Secour Bay. For example on Bon Secour Bay, over 100,000 scamp were observed during the winter of 1983-84 (D. Cooley, pers. comm. 1984).

Harvest figures for ducks and coots over the years 1972 to 1983 in the Mobile Delta are presented in Table 3. In general, more coots than ducks were harvested over the 12-year period, but the relative numbers varied by season.

SEA TURTLES

Turtle nesting is extremely rare in the northeastern Gulf of Mexico. The Atlantic small loggerhead (Caretta caretta) is reported to occur and occasionally nest in the area (Mount 1975; Boschung 1976; McDiarmid 1978). The

Table 3. Duck kill and hunting pressure in the Mobile Delta (1972-83 seasons) (B. Johnson, Alabama Department of Conservation, Montgomery, 1984; pers. comm.).

Year	Hunters checked	Hours hunted	Hours/ hunter	Ducks checked	Ducks/ hunter	Coots checked	Coots/ hunter
1972	220	592	2.69	186	.85	674	3.06
1973	270	720	3.54	665	2.46	865	3.20
1974	85	280	3.30	126	1.50	101	1.20
1975	279	1,001	3.58	492	1.76	1,419	5.08
1976	217	732	3.37	354	1.60	644	2.90
1977	281	664	2.36	568	2.0	593	2.10
1978	336	1,361	4.05	872	2.59	899	2.64
1979	297	1,015	3.40	389	1.34	517	1.74
1980	288	1,070	3.70	468	1.63	345	1.20
1981	210	830	3.86	628	3.00	328	1.65
1982	221	934	4.23	629	2.85	603	2.73
1983	268	953	3.56	365	1.36	533	1.99
TOTAL	2,972	10,152	3.42	5,742	1.93	7,521	2.53

beaches of nearby Florida are more likely nesting sites for turtles than the beaches of Alabama.

Four other species of sea turtles are believed to occur in coastal Alabama waters. These include the green turtle (Chelonia mydas), the Atlantic hawksbill (Eretmochelys imbricata imbricata), the Atlantic ridley (Lepidochelys kempi), and the Atlantic leatherback (Dermochelys coriacea). Green, hawksbill, and ridley turtles are occasional visitors in Alabama waters and are rarely encountered; however, leatherback turtles are not uncommon. While coastal Alabama beaches may have been within the nesting ranges of these four species at one time, they are not known to nest there now.

All five species of sea turtles found in Atlantic and Gulf of Mexico waters are protected by both Federal and state laws (Boschung 1976).

GRASS BEDS

The submerged aquatic vegetation (SAV) found in the Mobile Bay estuarine system are either freshwater, brackish-water, or marine species. In the delta area, the freshwater species Vallisneria americana (tape grass) and Myriophyllum spicatum (Eurasian milfoil) are most common (Stout and Lelong 1981). Vallisneria is a valuable waterfowl food and provides protection for young fishes in spawning areas (Beashears 1979), but Myriophyllum is an imported nuisance species. In the brackish-water areas, Ruppia maritima

(widgeongrass) is the dominant seagrass throughout the Mobile Bay and Perdido Bay systems. It serves as a primary food source for ducks and marsh birds (Stout and Lelong 1981). The most common seagrass in marine areas is Halodule wrightii (shoalgrass). It is prevalent at the entrance to Perdido Bay and in Mississippi Sound (Stout and Lelong 1981). Intermingled with Halodule plants, but in lesser numbers, are patches of Thalassia testudinum (turtlegrass) (Stout and Lelong 1981). Thalassia is the most abundant seagrass in the Gulf of Mexico as a whole, although it is less common in Alabama waters. All of these grasses contribute detritus to estuarine and marine systems and are important as primary producers, but their most valuable function is to provide protected nursery areas for larval and immature finfish and shellfish.

The mapped grassbeds on the atlas quad sheets utilize the most recently available data (Stout and Lelong 1981, 1982) but are not differentiated by species. Figure 2 shows a comparison of submerged aquatic vegetation along the lower Mobile Delta from 1957 to 1981. Since early inventories utilized differing methodologies, exact changes in areal coverage and species composition are difficult to assess. However, it appears that overall species diversity and total areal coverage have declined. Eurasian watermilfoil has become the predominate species in Alabama and is expected to increase in the future. The total area of submerged aquatic vegetation in Mobile and Baldwin Counties is estimated to be approximately 5,500 acres with the largest area (4,300 acres) in the Mobile Delta. Eurasian watermilfoil accounts for approximately 35% of total SAV acreage (Stout and Lelong 1981).

SHELLFISH HARVEST AREAS

Shrimp (Panaeus spp.)

The shrimp fishery is the most important commercial fishery in Alabama. Since 1950, when the annual catch was approximately 5,000,000 lb, the amount of shrimp landed in Alabama annually has generally increased, although variations in this trend have occurred (Figure 3). In 1977, a peak year, the shrimp fishery landed approximately 25,000,000 lb of shrimp which comprised 72% of the weight and 91% of the value of the total Alabama seafood landings (Heath 1979). Landings in 1983 totaled more than 15,000,000 lb with a value of over $40,000,000, 93% of the total value of seafood landings in Alabama (Table 4). There is some indication that catch per unit of effort has declined and that the present rate of exploitation is near maximum (Swingle 1977).

Ninety-nine percent of the shrimp caught off coastal Alabama spend at least part of their life cycle in the estuaries of Alabama; Mobile Bay is 77% of this system. Three shrimp species -- brown shrimp (P. aztecus), white shrimp (P. setiferus) and, to a limited extent, pink shrimp (P. duorarum) -- are commercially important species harvested off coastal Alabama (Heath 1979). All shrimp spawn offshore. Peak immigration of post-larvae into the estuaries is from March to April for brown shrimp and June to September for white shrimp (Christmas and Etzold 1977). Juvenile brown and white shrimp leave the estuaries for deeper waters in the spring and fall, respectively

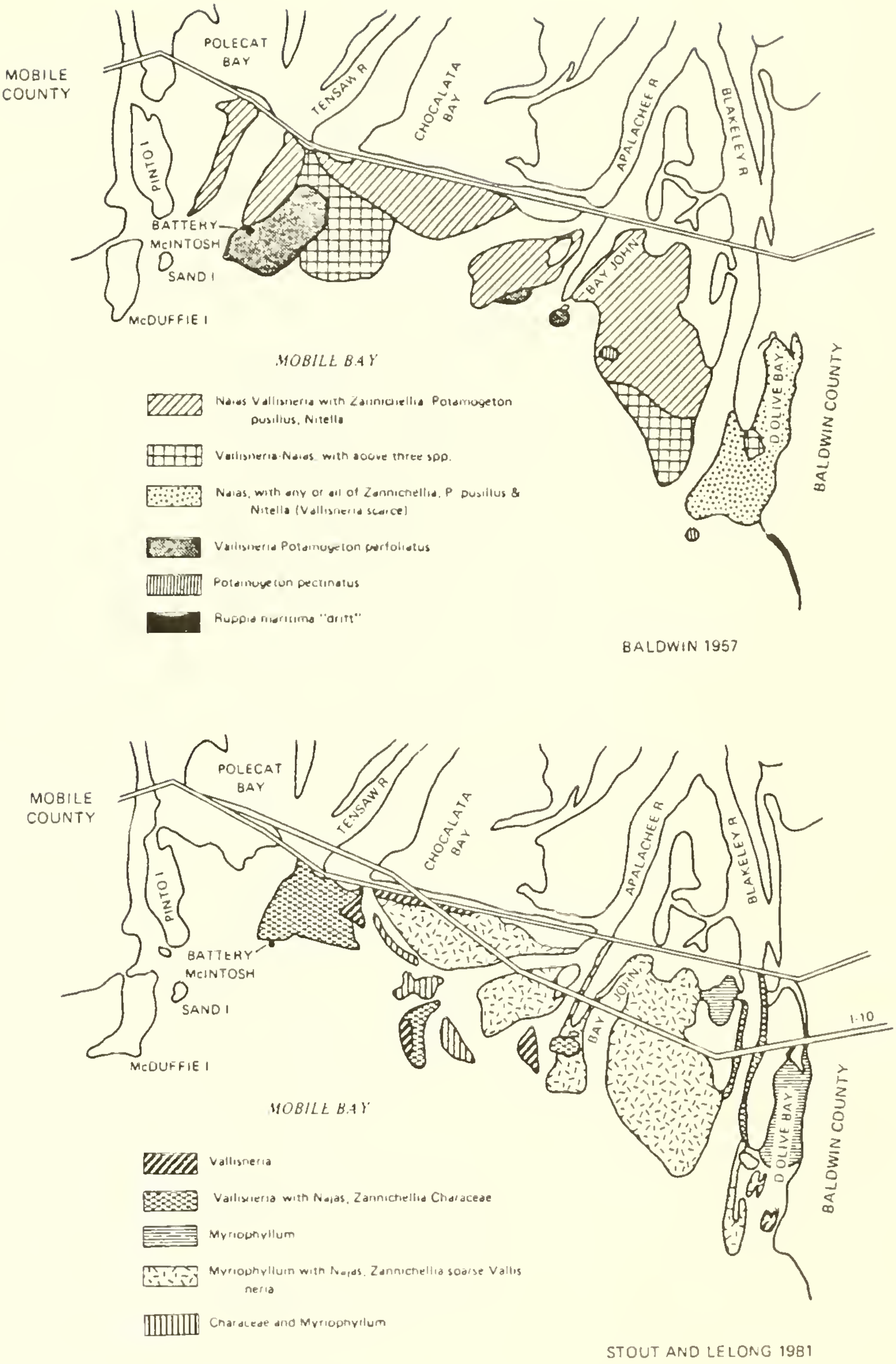

Figure 2. Comparison of submerged aquatic vegetation along lower Mobile Delta in 1957 and 1981 (Stout and Lelong 1981).

(Benson 1982). Brown and white shrimp are caught in the deeper estuarine waters as well as offshore.

Blue Crab (*Callinectes sapidus*)

The annual blue crab harvest has trended upward since 1950 (Tatum 1979), although there have been year-to-year fluctuations (Figure 4). In 1981, a

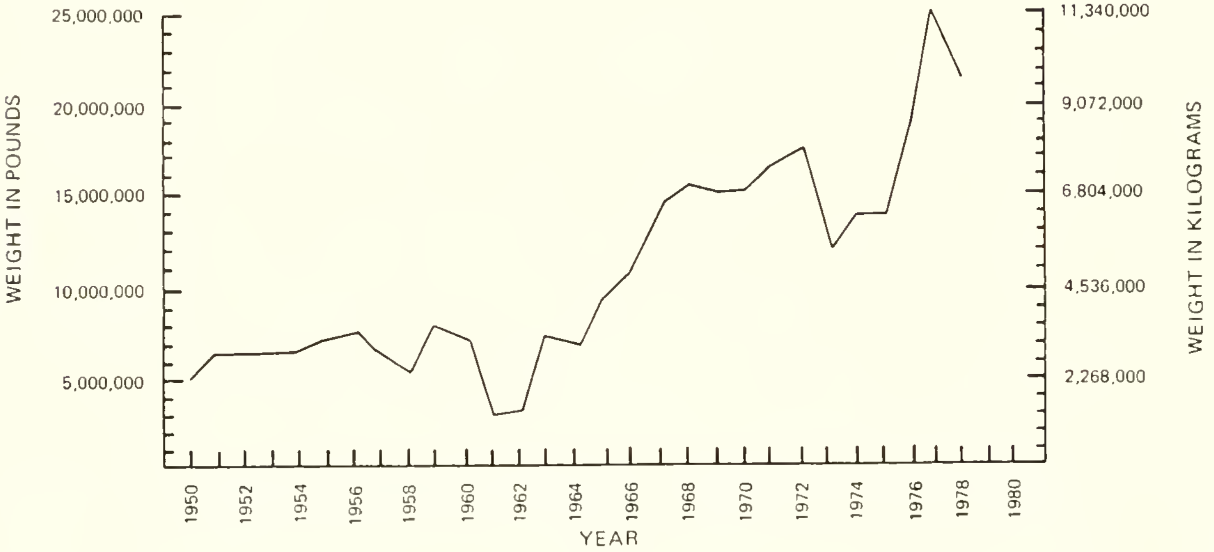

Figure 3. Total landings of shrimp in Alabama since 1950 (O'Neil and Mettee 1982).

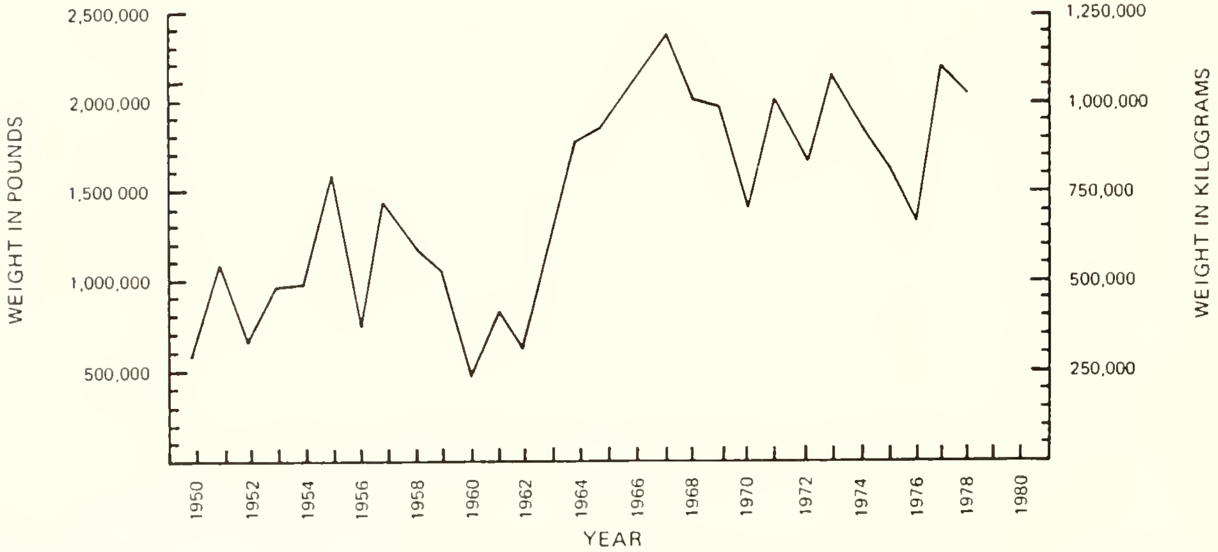

Figure 4. Total landings of blue crab in Alabama since 1950 (O'Neil and Mettee 1982).

peak year, the commercial harvest totaled almost 2.5 million lb (Table 4). Recently catch per unit of effort has declined and the data indicate the fishery is near the maximum substainable yield (Swingle 1977).

Most crabs are taken in traps with about 5% caught in shrimp trawls. Catch data for recreational crabbing are unavailable, but it may approach 20% of the total catch (Tatum, unpubl.). The crabs ovulate and mate in Mobile Bay and its estuarine system. Adult females spawn around and south of the barrier islands; the larvae undergo a period of development in open gulf waters. They move into the estuary when they have reached the postlarval stage (Benson 1982). Larval crabs grow to harvestable size in 12 months.

Oyster Reefs (*Crassostrea virginica*)

A recent review of the American or eastern oyster (*Crassostrea virginica*) fishery in Alabama by Eckmayer (1979) is the basis for the following material. The eastern oyster is the most economically important mollusk species in Alabama. The oyster landing for Alabama in 1978 was 760,000 lb and in 1983, 417,153 lb (Table 4). The total area of oyster reefs has remained relatively constant since 1894 at approximately 1200 ha (2965 acres), but has shifted southward due to environmental factors. Productivity may decrease in the future due to overfishing. One of the largest reefs is Cedar Point Reef (Biloxi quadrangle). This reef has been subject to major fluctuations in size since it was first fished in the 1800's; in 1968 it covered 563 hectares (1,391 acres). Cedar Point Reef was temporarily closed in 1978 because overfishing in 1977 had severely reduced the oyster population.

Sand Reef (Biloxi quadrangle), the second largest in Mobile Bay, decreased 92% from 1952 to 1968. The change was due primarily to sedimentation. It was spread with clam shells to increase the area, but the effort was only partially successful, since some of the shells sank into the mud substrate. However, by 1979 the densest oyster population in all of Mobile Bay was on Sand Reef (Eckmayer 1979).

Factors affecting oyster populations are lowered dissolved oxygen levels, salinity, predators, disease, and overfishing.

Spoil materials from dredging have covered and destroyed some parts of Alabama oyster reefs in the past. Dredging for the Gulf Intracoastal Waterway altered salinity in some areas. Since oysters are found mostly in areas with salinities between 10 to 20 ppt, floods of freshwater from rivers can result in a short-term reduction in reef populations, or even mass mortalities. Apparently, though, floods have caused relatively little long-term damages in Mobile Bay. The benefits of the freshwater, such as control of diseases and predators, may compensate for losses to the oyster population (Eckmayer 1979).

The most important oyster predator is the southern oyster drill (*Thais haemostoma*), for which there is no effective man-made control. Drill populations are naturally controlled by freshwater floods. Drills cannot survive long periods in water less than 15 ppt salinity. When freshets

Table 4. Commercial landings of selected finfish and shellfish at Alabama ports in 1978-83 (National Marine Fisheries Service 1978-83).

Species	1978 Landing (1,000 lb)	1978 Value (dollars)	1979 Landing (1,000 lb)	1979 Value (dollars)	1980 Landing (1,000 lb)	1980 Value (dollars)
Finfish						
Croaker	2,421.1	423,553	4,134.2	665,401	7.1	2,232
Flounders	638.6	209,647	67.1	271.674	501.2	225,802
Groupers	68.7	32,091	69.8	29,635	50.1	23,939
Mullet	933.4	158,797	649.3	117,377	622.3	127,042
Pompano	9.7	5,064	10.2	7,805	9.8	10,743
Sea trout, spotted	31.7	18,495	74.2	45,083	26.0	24,401
Sea trout, white	779.5	126,207	796.3	145,589	775.2	153,204
Snapper, red	426.3	314,535	535.3	457,695	417.6	423,100
Spanish mackerel	27.8	4,058	112.5	24,999	50.8	6,706
Shellfish						
Crabs, blue	2,008.9	438,148	1,340.7	390,823	1,556.7	464,583
Oysters (meat)	760.0	846,833	460.3	479,137	54.8	72,265
Shrimp (heads-on)	21,133.5	32,747,678	20,408.5	48,431,296	15,157.9	30,658,698

occur, the drills burrow into the mud and await the return of more saline waters. If the freshet is of sufficient duration, the drills die. This is the most effective control method known at this time (Eckmayer 1979). The most destructive oyster disease is "dermo," which is caused by a protozoan, Perkinsus marinus. Oysters are most susceptible to infection in the summer during times of high salinity and the result is swift die-off.

The Dauphin Island Oyster Reef (Biloxi quadrangle) was the only active oyster reef remaining after Hurricane Frederic in 1979. Oysters from this reef were used to restock destroyed beds in other areas. Oyster abundance in Alabama should have been restored to normal by 1982, but floods in 1983 resulted in losses of over 32% of the oysters (U.S. Army Corps of Engineers 1983). The abundance of oysters for harvest is affected by bacterial pollution in Mobile Bay. The Alabama Department of Health closes the Mobile Bay oyster reefs during periods of increased bacterial count. Reef closures generally occur when flooding increases the freshwater influx into the bay. Somewhat more than 72,000 acres, mostly in the northern parts of Mobile Bay, have been permanently closed to shellfish harvesting (O'Neil and Mettee 1982). Since oyster availability tends to fluctuate considerably, most oyster fishermen do not rely solely on oysters for their livelihood (Friend et al. 1981). Figure 5 indicates variation in oyster landings from 1950 to 1981.

FINFISH OF COASTAL ALABAMA

Data on recreational and commercial harvests of species discussed in the narrative are shown in Tables 4 and 5. Data on habitats and spawning loca-

Table 4. (concluded)

1981		1982		1983	
Landing (1,000 lb)	Value (dollars)	Landing (1,000 lb)	Value (dollars)	Landing (1,000 lb)	Value (dollars)
4,706.5	1,480,022	1,621.2	593,424	436.9	142,553
585.2	304,313	624.4	303,108	509.9	284,083
68.5	40,535	36.5	25,880	48.4	40,403
523.6	187,468	684.6	141,752	566.9	147,893
3.3	2,396	5.1	9,932	1.4	1,055
26.7	23,019	62.6	54,747	59.5	55,625
656.5	140,402	713.5	180,640	363.0	93,115
503.1	653,209	580.6	757,703	535.2	651,316
56.9	13,781	50.5	12,916	58.3	14,474
2,462.3	849,922	1,266.2	478,987	1,411.6	614 299
1,329.9	2,002,392	1,496.9	2,150,500	355.6	417,153
21,246.9	38,096,113	16,797.0	41,400,000	15,416.0	40,025,000

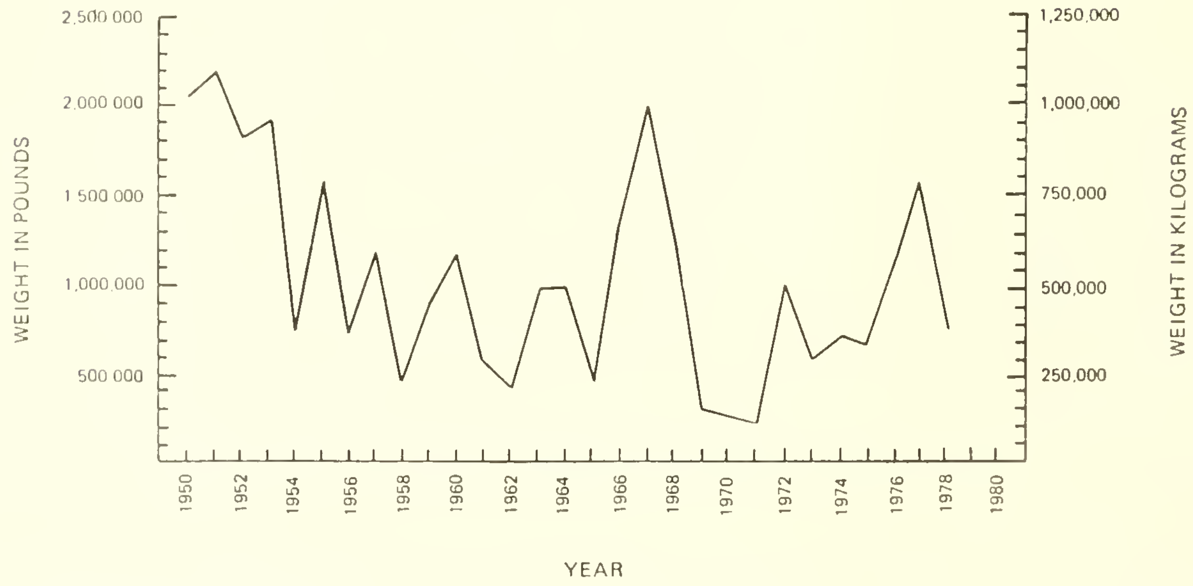

Figure 5. Total landings of oysters in Alabama since 1950 (O'Neil and Mettee 1982).

Table 5. Estimated recreational catch (pounds) of marine finfish in Alabama during 1975 (Wade 1977).

Species	Private boat fishery	Pier fishery	Shoreline fishery	Charter boat fishery	Total
Croaker	441,477	40,715	43,957	---	526,149
Flounder	76,884	44,869	4,476	---	126,229
Grouper	---	---	---	3,850	3,850
King mackerel	939,054	38,438	---	76,494	1,053,986
Mullet	42,583	2,855	35,062	---	80,500
Pompano	---	1,267	64	---	1,331
Red drum	306,719	35,723	44,690	---	387,132
Sand seatrout	483,822	17,586	18,893	---	520,301
Snapper	79,410	1,750	---	57,882	139,042
Spanish mackerel	920,622	26,589	---	14,498	961,709
Spotted seatrout	774,740	14,679	9,218	---	798,637

Note: A new saltwater sport fishing survey is due to be conducted in October 1984 (W. Tatum, Alabama Department of Conservation, Marine Resources Division, July 1984; pers. comm.).

tions is presented in Figure 6. Location and data on artifact fishing reefs is included in the socieconomics narrative.

Florida Pompano (Trachinotus carolinus)

Juvenile pompano are very abundant along the gulf beaches of Alabama from May to September (Swingle 1977), but most migrate southward later in the fall and few adult fish are caught in this area of the gulf. All netting within 1.6 km (1 mi) of the Alabama coast is prohibited from May 1 to Labor Day, except for shrimp trawls and purse seines. This fishery will probably remain relatively minor in the state (Swingle 1977).

Mackerels (Scomberomorus spp.)

Spanish mackerel (S. maculatus) and king mackerel (S. cavalla) are found along the gulf coast of Alabama, especially in the spring and summer months. Because of their proximity to shore, Spanish and king mackerel are the most abundant fishes (by weight) caught by recreational fishermen (Wade 1977). Spanish mackerel play an insignificant part in the total commercial harvest, as most are caught incidentally by shrimp trawls (Swingle 1976). King mackerel have been harvested commercially in Florida and Louisiana since 1981 (Swingle 1983).

FINFISH AND SHELLFISH OF COASTAL ALABAMA CATEGORY COMMON NAME	SPAWNING LOCATION	SPAWNING SEASON												NURSERY AREA	MAJOR LARVAL HABITATS					AREA OF ADULT ABUNDANCE	MAJOR ADULT HABITATS					MIGRATION TYPE
		Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec		Seagrass	Saltmarsh	Beaches	Artificial Reefs	Open Water		Seagrass	Beaches	Open Water	Saltmarsh	Artificial Reefs	
ESTUARINE DEPENDENT FISHES																										
Florida Pompano	C				●	●	●	●	●	●	●			C-B			●			B		●	●		●	1
Gulf Menhaden	C	●	●	●							●	●	●	E	●	●	●			C-E	●	●	●			2
Spotted Seatrout	C-E						●	●	●					E	●	●				C-E	●					1
Southern Flounder	ICS	●	●	●	●					●	●	●	●	C-E	●	●	●			C-E	●	●		●		1
Atlantic Croaker	C-E	●	●	●	●						●	●	●	C-E	●	●	●			C-E	●	●				1
Striped Mullet	CS	●	●	●	●	●					●	●	●	C-E	●	●				C-E	●	●				1
Red drum	C-E									●	●	●		E	●	●				E	●	●		●		1
REEF FISH																										
Red Grouper	CS				●	●	●	●	●					C-E				●		CS					●	1
Red Snapper	CS						●	●	●	●	●			C	●			●		C					●	1
COASTAL PELAGIC FISHES																										
King Mackerel	CS			●	●	●	●	●						ICS					●	C					●	3
Spanish Mackerel	CS			●	●	●	●	●						E-C					●	C					●	3
SHELLFISH																										
Brown Shrimp	C	●	●	●	●							●	●	E		●				C			●			
White Shrimp	C			●	●	●	●	●	●	●	●			E		●				C-E		●	●			
Blue Crab	C-E					●	●	●	●	●				E		●				C-E		●	●	●		

KEY

E - Estuarine
B - Beach
C - Coastal

CS - Continental Shelf
ICS - Inner Continental Shelf

MIGRATION TYPE

1 - Random Residential Range
2 - Restricted Migration
3 - Extensive Migration

Figure 6. Finfish and shellfish of coastal Alabama.

Gulf Menhaden (Brevoortia patronus)

The most abundant fish (by weight) caught commercially off the Alabama coast are menhaden (Wade 1977). None were landed in Alabama, however, since most go to processing plants in Mississippi. Recreationally, menhaden are not caught in numbers for consumption but rather as bait for more popular species of recreational fish. Gulf menhaden spawn offshore from mid-October through March. The larvae move into estuaries from February to May and disperse into quiet shallow waters near shore. Juveniles move out of the shoreline areas from May to July and form large schools in the deeper open parts of the estuaries. Juveniles and subadults migrate from estuaries into

offshore waters from December through February. Larger gulf menhaden move from offshore areas into the estuaries during spring and summer, with adults migrating out of the estuary during September-November for the October-March spawning period. Purse seining for gulf menhaden takes place primarily in the Mississippi Sound, with some vessels venturing outside the barrier islands (Benson 1982).

Southern Flounder (Paralichthys lethostigma)

Loesch (1976c) found that southern flounder were widely distributed in Alabama coastal waters though they were not particularly abundant. Juvenile flounder were not abundant along the beaches, open bays, or marshes in 5 years of collecting (Loesch 1976c). Adults, however, are often taken by commercial and sport fishermen in shallow coastal waters. The majority of the flounder captured commercially are taken incidentally by shrimp trawls (Swingle 1976). Sport fishermen take flounder both by hook and line, and gig.

Croaker (Micropogonias undulatus)

The croaker is the second most abundant species by weight (after menhaden) taken commercially off Alabama (Wade 1977). The majority of the croaker harvest is by shrimp trawl (Swingle 1977). Croaker are also popular with sport fishermen. Sampling by Swingle and Bland (1974b) indicates that spawning occurs from late September or early October to April, with peaks of spawning activity varying with climatological changes. This species spawns over a wide area, from the passes at the mouth of the bay to oceanic waters many miles offshore; juveniles migrate to the Mississippi Sound in late spring and early summer. In late summer and fall croakers migrate toward Gulf waters. Few croakers remain in inside waters for more than 1 year. Croakers have a high mortality rate and rarely live more than 4 or 5 years (Benson 1982).

Groupers (Epinephelus and Mycteroperca spp.)

Groupers inhabit and spawn on offshore reefs. The abundance of this species is dependent on the availability of habitat (Swingle 1977). Commercially, the majority of groupers harvested by the Alabama fleet are taken in the offshore waters of Louisiana, Texas, and Mexico (Swingle 1977). The abundance of grouper near reefs makes charter and party boat fishing for them popular. Many groupers are taken near the artificial reefs discussed in the socioeconomic narrative.

Snappers (Lutjanus spp.)

In recent years there has been a decline in the Alabama snapper fishery due to over-exploitation of the species and the reduction in size of the Alabama snapper fleet (Swingle 1977). Most of the snapper harvest comes from Louisiana, Texas, Mexico, and Central America (Swingle 1977). The red snapper (Lutjanus campechanus) is the most common snapper in coastal Alabama waters and is found in deep offshore waters around coral, natural or man-made submerged objects, and hard sand bottoms (Benson 1982).

Mullets (*Mugil* spp.)

Mullets are abundant in Alabama and contribute significantly to the total harvest of fish. Fishing is primarily inshore (Swingle 1977), where mullet are found in tidal rivers and bay waters (Swingle and Bland 1974b). The market price for mullet is low and the commercial harvest is declining (Swingle 1977). Recreational fishermen harvest mullet by line and cast net.

Red Drum (*Sciaenops ocellatus*)

Red drum are not a commercially valuable fish species in Alabama. They are found along the shore in shallow waters, where they are more easily accessible to sport fishermen. Most of the red drum harvested are by private boat or by shoreline and pier fishing. They are the largest fish caught by these anglers and are usually taken during spawning (Wade 1977).

Sardines (*Anchoa* spp.)

The sardine fishery is not an important industry off Alabama shores. The only nearby sardine fishery is off Florida and is relatively insignificant (Wade 1977).

Seatrout (*Cynoscion* spp.)

There are three species of seatrout found along the Alabama coast (Swingle 1977). Sand seatrout (*C. arenarius*) and silver seatrout(*C. nothus*) are primarily caught offshore by shrimp trawls (Swingle 1977). Sand seatrout may also be found in estuaries during cooler months where they are caught by sport fishermen. Spotted seatrout (*C. nebulosus*) are commonly found in Mobile Bay and its tributaries. They are important to both commercial and sport fisheries (Swingle and Bland 1974b). In fact, spotted seatrout may be the most important sport fish caught in Alabama coastal waters. The major saltwater river fishing for seatrout is in the Mobile Delta, the Fish River, and the Bon Secour River. In these areas fishing is good around submerged objects and near bridges. The fishing season ends in mid-February when drainage from rains reduces the salinity in the rivers. Juvenile seatrout are found in tidal creeks less commonly than adults, but juveniles do inhabit open-bay areas in grassbeds (Swingle and Bland 1974b).

ENDANGERED AND THREATENED SPECIES OF MOBILE AND BALDWIN COUNTIES, ALABAMA

Coastal Alabama provides habitat for vulnerable species, both plant and animal, that receive a high degree of public concern and are subject to legislative protection. These species are not mapped in this atlas in order not to contribute to the decline of their numbers. The U.S. Fish and Wildlife Service (USFWS) (Endangered Species Field Office, 300 Woodrow Wilson Avenue, Jackson, Mississippi 39213, telephone 601-490-4900) will provide detailed information if contacted by industries and agencies planning projects impacting Mobile and Baldwin Counties. For State of Alabama coordination, please contact the Alabama Department of Conservation, 64 North Union Street, Montgomery, Alabama 36130, telephone (205) 261-3471.

Unless otherwise specified, the following information is summarized from "Endangered and threatened species of the southeastern United States" (U.S. Fish and Wildlife Service 1975, with updates, January 1982) (Table 6) and "Endangered and threatened plants and animals of Alabama" (Boschung 1976) (Table 7). The information has been updated in accordance with Federal listings through June 1985. Although the state of Alabama does not maintain an official (legally binding) list of their endangered and threatened species, the Boschung (1976) publication is used as a guide by natural resource personnel in the state.

Mammals

The West Florida manatee, *Trichechus manatus*, usually winters along the southern Florida coast, particularly in rivers and estuaries, and migrates north along the coast as far as North Carolina and western Florida. It is occasionally reported from Mississippi, and therefore is at least a transient in Alabama waters (Dan O'Dell, Rosenstiel School of Marine and Atmospheric Science, Miami, FL, 11 March 1982; pers comm.).

The Florida panther, *Felis concolor coryi*, has recently been reported from Baldwin County. The state population, if it exists, is quite small, perhaps less than a dozen. Panthers are found in large, remote riverine swamps and forested areas.

The blue whale, *Balaenoptera musculus*; the finback whale, *B. physalus*; the sei whale, *B. borealis*; the humpback whale, *Megaptera novaeangliae*; and the sperm whale, *Physeter catodon*; are unknown in Alabama coastal waters, although the sperm whale was at one time present in some numbers in the Gulf of Mexico (Dan O'Dell, 11 March 1982; pers. comm.)

The Alabama beach mouse, *Peromyscus polionotus ammobates*, and the Perdido Key beach mouse, *P. p. trissyllepsis*, as of June 1985 was listed as endangered by the U.S. Fish and Wildlife Service (*Federal Register* 1985).

The Alabama beach mouse presently survives on disjunct tracts of the sand dune system from Fort Morgan State Park to the Romar Beach area, but has apparently disappeared from most of its original range, including all of Ono Island. Tropical storms and loss of habitat are considered to be primary factors for the mouse's decline. It is estimated that less than half of the original habitat still remains suitable.

The Perdido Key beach mouse, like the Alabama beach mouse, prefers remote beach dunes. It currently survives on the western part of Perdido Key including the Gulf State Park, Baldwin County, Alabama. Tropical storms and loss of habitat are considered to be primary factors for the mouse's decline. It is estimated that about 34% of the island has been developed and is no longer suitable habitat for the species.

The Florida black bear, *Ursus americanus floridanus*, is probably restricted in Alabama to densely forested river bottoms. Its population has been estimated by the Alabama Department of Natural Resources at about 65 to 70 statewide, with about 30 individuals in Mobile County and 15 in Baldwin

Table 6. Federally listed endangered and threatened species of Mobile and Baldwin Counties, Alabama (U.S. Fish and Wildlife Service January 1982; U.S. Department of the Interior 1975; Federal Register 1985).

Status[a]	Species	Alabama range
Mammals		
E	Florida manatee (*Trichechus manatus*)	Coastal waters
E	Florida panther (*Felis concolor coryi*)	Entire State
E	Blue whale (*Balaenoptera musculus*)	Coastal waters
E	Finback whale (*Balaenoptera physalus*)	Coastal waters
E	Sei whale (*Balaenoptera borealis*)	Coastal waters
E	Humpback whale (*Megaptera novaeangliae*)	Coastal waters
E	Sperm whale (*Physeter catodon*)	Coastal waters
E	Alabama beach mouse (*Peromyscus polionotus ammobates*	Coastal dunes
E	Perdido Key beach mouse (*Peromyscus polionotus trissyllepsis*	Coastal dunes
Birds		
E	Bald eagle (*Haliaeetus leucocephalus*)	Entire State
T	Arctic peregrine falcon (*Falco peregrinus tundrius*)	Entire State
E	Bachman's warbler (*Vermivora bachmanii*)	Entire State
E	Ivory-billed woodpecker (*Campephilus principalis*)	South, West Central
E	Red-cockaded woodpecker (*Picoides [=Dendrocopos] borealis*)	Entire State
Reptiles		
E	American alligator (*Alligator mississippiensis*)	Coastal plain
E	Kemp's (Atlantic) Ridley turtle (*Lepidochelys kempii*)	Coastal waters
E	Hawksbill turtle (*Eretmochelys imbricata*)	Coastal waters
E	Leatherback turtle (*Dermochelys coriacea*)	Coastal waters
T	Loggerhead turtle (*Caretta caretta*)	Coastal waters
T	Green sea turtle (*Chelonia mydas*)	Coastal waters
T	Eastern indigo snake (*Drymarchon corais couperi*)	South Alabama
Plants		
	None as of January 1, 1982	

[a]E = Endangered, T = Threatened.

Table 7. Recommended State of Alabama endangered and threatened species of Mobile and Baldwin Counties (Boschung 1976; Freeman et al. 1979).

Recommended status[a]	Species
Mammals	
E	Alabama Gulf beach mouse, *Peromyscus polionotus ammobates*
E	Perdido Bay beach mouse, *Peromyscus polionotus trissyllepsis*
E	Florida black bear, *Ursus americanus floridanus*
E	Florida panther, *Felis concolor coryi*
Birds	
E	Bald eagle, *Haliaeetus leucocephalus*
E	Peregrine falcon, *Falco peregrinus*
E	Osprey, *Pandion haliaetus*
E	Snowy plover, *Charadrius alexandrinus*
E	Ivory-billed woodpecker, *Campephilus principalis*
E	Red-cockaded woodpecker, *Picoides (=Dendrocopos) borealis*
E	Bachman's warbler, *Vermivora bachmanii*
T	Mottled duck, *Anas fulvigula*
T	Reddish egret, *Egretta rufescens*
Reptiles	
E	Eastern indigo snake, *Drymarchon corais couperi*
E	Black pine snake, *Pituophis melanoleucas lodingi*
E	Atlantic loggerhead turtle, *Caretta caretta*
E	Green sea turtle, *Chelonia mydas*
E	Atlantic hawksbill turtle, *Eretmochelys imbricata imbricata*
E	Atlantic ridley turtle, *Lepidochelys kempi*
T	American alligator, *Alligator mississippiensis*
T	Atlantic leatherback turtle, *Dermochelys coriacea*
T	Alabama red-bellied turtle, *Pseudemys (=Chrysemys) alabamensis*
T	Gopher tortoise, *Gopherus polyphemus*
Amphibians	
E	Flatwoods salamander, *Ambystoma cingulatum*
T	Dusky gopher frog, *Rana areolata sevosa*
Fishes	
T	Atlantic sturgeon, *Acipenser oxyrhynchus*
T	Blue sucker, *Cycleptus elongatus*

(continued)

Table 7. (continued)

Recommended status	Species	Habitat assoc. (County)[b]
Plants		
	Aquifoliaceae	
E	Ilex amelanchier	Acid swamp woodlands (M)
	Araceae	
T	Sweet flag, Acorus calamus	Shallow streams (B)
T	Spoon flower, Peltandra sagittaefolia	Pineland bogs (B)
	Cannaceae	
T	Golden canna, Canna flaccida	Freshwater swamps (MB)
	Cyperaceae	
E	Horned rush, Rhynchospora crinipes	Pine savannahs (M)
	Ericaceae	
T	Pieris phillyreifolia	Probably no longer in counties (MB)
	Fabaceae	
E	Psoralea simplex	Wet pinelands (M)
	Gentianaceae	
E	Gentiana villosa	Oak-pine-hickory woods (M)
T	Sabatia brevifolia	Pinelands (B)
	Hypericaceae	
T	St. Johns wort, Hypericum nitidum	Acid pine savannah (M)
	Juncaceae	
T	Juncus gymnocarpus	Swamp woodlands (M)
	Lentibulariaceae	
T	Bladderwort, Utricularia floridana	Low pH ponds (M)
T	Bladderwort, Utricularia inflata	Lakes (M)
T	Bladderwort, Utricularia purpurea	Low pH streams (BM)
	Liliaceae	
E	Lily, Lilium iridollae	Acid swamp woodlands (B)
	Onagraceae	
T	Ludwigia arcuata	Pond banks (M)
E	Evening primrose, Oenothera grandiflora	Rich low woodlands (B)
	Orchidaeceae	
T	Spreading pogonia, Cleistes divaricata	Pineland bogs (MB)
E	Green-fly orchid, Epidendrum conopseum	Epiphytic gum/ magnolia (MB)
	Poaceae	
T	Panicum nudicaule	Acid swamps (MB)
	Potamogetonaceae	
E	Pondweed, Potomogeton robbinsii	Streams, Mobile Delta (MB)

(continued)

Table 7. (concluded)

Recommended status	Species	Habitat assoc. (County)
Plants		
	Rhamnaceae	
T	*Segeretia minutiflora*	Mobile beaches (M)
	Sarraceniaceae	
T	Pitcher-plant, *Sarracenia psittacina*	Wet pine flatwoods (MB)
T	Sweet pitcher-plant, *Sarracenia rubra*	Wet pine flatwoods (B)
	Theaceae	
T	Loblolly bay, *Gordonia lasianthus*	Pocosin borders (MB)
	Ulmaceae	
T	*Momisia iguanea*	Beach strands (MB)
	Xridaceae	
T	Yellow-eyed grass, *Xyris drummondii*	Acid sandy sites (MB)
T	Yellow-eyed grass, *Xyris scabrifolia*	Wet pinelands (MB)

[a]E = Endangered; T = Threatened.
[b]M = Mobile; B = Baldwin.

County (Jim Davis, Alabama Department of Conservation and Natural Resources, Jackson, AL, 11 March 1982; pers. comm.).

Birds

The bald eagle, *Haliaeetus leucocephalus*, ranges throughout the state as a migrant, and formerly nested in Mobile and Baldwin Counties. Although bald eagles are known to nest in Louisiana, Florida, Mississippi, and South Carolina, they rarely nest elsewhere in the Southeast.

The Arctic peregrine falcon, *Falco peregrinus tundrius*, migrates through Alabama on its way from the arctic tundra regions to southern South America, and fairly numerous sightings (perhaps 30 per year) are made on the Fort Morgan Peninsula (Dennis Jordan, U.S. Fish and Wildlife Service, Jackson, MS, 11 March 1982; pers. comm.). Some individuals are believed to overwinter along the Gulf coast and southern Florida. The falcon has been recently reclassified from endangered to threatened (Federal Register, March 20, 1984).

Bachman's warbler, *Vermivora bachmanii*, is extremely rare, if not extinct. It may pass through Alabama in the spring on its migration from Cuba to widespread localities in the Southeast.

The ivory-billed woodpecker, Campephilus principalis, is probably extinct, as there have been no confirmed sightings since the 1930's. It apparently occupied virgin lowland hardwood forests across the Southeast (Tanner 1942).

The red-cockaded woodpecker, Picoides (Dendrocopos) borealis, is known from Baldwin County and surrounding areas, as well as from most Southeastern States. The nesting cavities this bird requires are found only in pine trees older than 60 years, usually with red heart disease. Decreasing habitat is probably responsible for this species' decline.

The osprey, Pandion haliaetus, is found nearly worldwide in tropical and temperate areas near water. It was formerly a breeding inhabitant along the Gulf Coast, as well as a migrant throughout Alabama. Its numbers dropped drastically as a result of pesticides in the 1960s, until they were considered rare. A single nest was found near the Gulf coast in 1974 and an active nest was reported on Fort Morgan in 1982 (O'Neil and Mettee 1982). Ospreys are also reported to nest along Bon Secour Bay (Dwight Cooley, U.S. Fish and Wildlife Service 1984; pers. comm.).

The snowy plover, Charadrius alexandrinus, was previously known from Mobile and Baldwin Counties as a permanent breeding resident on the beach and sandy areas, particularly away from human encroachment. As human activities are increasing in these areas, this species is becoming rare.

The mottled duck, Anas fulvigula, is an uncommon, but permanent, resident on outer islands, peninsulas, and sheltered bays, and often overwinters in the upper reaches of Mobile Bay (Imhof 1976).

The reddish egret, Egretta rufescens, is sometimes fairly common in Alabama. Although not known to breed in the study area, it is a permanent year round resident. It is most common in the shallow bays, mud flats, and sand beaches on the inshore side of barrier islands (Imhof 1976).

Reptiles

The American alligator, Alligator mississippiensis, ranges from North Carolina to Texas. Alligators are ordinarily found in streams and lakes, especially in swampy areas such as those that constitute the Mobile Bay delta, as well as in brackish water along the coast. There are widely scattered small populations within their original distribution, which extends inland nearly to the fall line (Mount 1975). As a result of protective measures their numbers have recently increased; they have been reduced in status on Alabama's recommended endangered list but are still considered threatened (O'Neil and Mettee 1982).

The Kemp's ridley sea turtle (Lepidochelys kempii), the green sea turtle (Chelonia mydas), and the Atlantic hawksbill turtle (Eretmochelys imbricata) are only occasional visitors to Alabama coastal waters and are not numerous.

The leatherback turtle, Dermochelys coriacea, is worldwide in distribution in tropical waters, although it ranges into fairly cool water

(Mount 1975). This species is often captured in June by shrimp trawlers off Dauphin Island in about 13 m (42 ft) of water.

The loggerhead turtle, Caretta caretta, is the most common sea turtle in Alabama waters, and has been recorded from both Mobile and Baldwin County waters. Although known to nest on the seaward beaches of Dauphin Island in the past, the only recent records are from the Fort Morgan Peninsula (Mount 1975).

The eastern indigo snake, Drymarchon corais couperi, was originally recorded from both Baldwin and Mobile Counties, although there have been no sightings in this area since the 1930's. It prefers uplands with well-drained, sandy soil (Mount 1975).

The gopher tortoise, Gopherus polyphemus, and the black pine snake, Pituophis melanoleucas lodingi, may occur in the study area, and although not currently listed, are considered candidate species for listing by the U.S. Fish and Wildlife Service (Dennis Jordan 11 March 1982; pers. comm.)

The black pine snake is found in Mobile County and intergrades with Pituophis melanoleucas mugitus in Baldwin County. It prefers well-drained, sandy soil, such as the longleaf pine, turkey oak, and sandhill communities. Like the indigo snake, it is often found in gopher tortoise burrows.

Gopher tortoises are found on the Coastal Plain of Alabama in sandy, well-drained soils, particularly in longleaf pine, turkey oak, and sandhill communities. Their burrows provide necessary habitat for a variety of species , including snakes, frogs, insects, and mammals.

The Alabama red-bellied turtle, Pseudemys (=Chrysemys) alabamensis, is found almost exclusively in Mobile and Baldwin Counties in the lower portion of the Mobile Bay drainage from Little River southward. Its habitat includes sluggish rivers, oxbows, and lakes with abundant aquatic vegetation.

Amphibians

The flatwoods salamander, Ambystoma cingulatum, was previously reported from Mobile and Baldwin Counties, although the only recent records are from Covington County (and that population may have been extirpated). It is found in low pine flatwoods dominated by slash pine and wiregrass.

The dusky gopher frog, Rana areolata sevosa, is found from Florida to Louisiana and is known from both Mobile and Baldwin Counties. It is found where gopher tortoise burrows, which they use for shelter, are found close to the shallow, temporary, or semipermanent ponds, where they breed. The species may also use crawfish burrows in areas where no tortoise burrows are found.

Freshwater Fishes

The Atlantic sturgeon, Acipenser oxyrhynchus, was once common in the Mobile River Delta. The species ranges from nearshore in the gulf, up larger

rivers and estuaries, and into smaller rivers to spawn. The blue sucker, *Cycleptus elongatus*, is found in the larger rivers of coastal Alabama.

None of the crawfishes, shrimps, gastropods, or naiad mollusks on the recommended state list of endangered and threatened species are found in either Mobile and Baldwin Counties (Boschung 1976).

Plants

Fifty-eight species of plants found in Mobile and Baldwin Counties are classified as endangered, threatened, or of special concern (Freeman et al. 1979). On the state list 7 species are identified as endangered, 19 as threatened, and the remainder as of special concern. As of June 1985, six of these species were under consideration for inclusion on the Federal list of endangered and threatened species (vide *Federal Register* notice of November 28, 1983[48 FR 53640]). The counties and habitats of plants with recommended Alabama status is indicated in Table 7.

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Swingle, W. E. 1976. Analysis of commercial fisheries catch data for Alabama. Ala. Mar. Resour. Bull. 11:26-50.

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Loyacano, H. A., Jr., and J. P. Smith. 1979. Symposium on the natural resources of the Mobile Estuary, Alabama. Alabama Coastal Area Board, Mississippi-Alabama Sea Grant Consortium, and U.S. Fish and Wildlife Service. 290 pp.

O'Neil, P. E., and M. F. Mettee. 1982. Alabama coastal region ecological characterization. Vol. 2. A synthesis of environmental data. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-81/42. 346 pp.

Swingle, H. A. 1971. Biology of Alabama estuarine areas. Cooperative Gulf of Mexico Estuarine Inventory. Ala. Mar. Resour. Bull. 5. 123 pp.

U.S. Army Corps of Engineers. 1981. Report of basic environmental data of the State of Alabama. U.S. Army Corps of Engineers, Mobile District, Mobile. 326 pp.

U.S. Army Corps of Engineers. 1983. Mississippi Sound and adjacent areas. U.S. Army Corps of Engineers, Mobile District, Mobile. 275 pp.

SOURCES OF MAPPED INFORMATION

Wetland Habitats

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-79/31. 103 pp.

Contains an explanation and description of the categories developed to classify all wetlands in the United States. Contains photographic examples of each category.

U.S. Department of the Interior, Fish and Wildlife Service. Office of Biological Services. National Wetlands Inventory 7.5' 1:24,000 quadrangles, various dates.

Wetland areas mapped according to classifications developed in Cowardin et al. 1979.

Bird Resources

Gaston, G. R., and P. G. Johnson. 1977. Nesting success and mortality of nestlings in a coastal Alabama heron-egret colony, 1976. Northeast Gulf Sci. 1(1):14-22.

Holliman, D. C. 1978. Clapper rail (*Rallus longirostris*) studies in Alabama. Northeast Gulf Sci. 2(1):24-34.

The habitat and distribution of the clapper rail *Rallus longirostris saturatus* in salt and brackish-mixed marshes of Alabama is described. A total of 4,490 ha (11,095 acres) of habitat is mapped. Smaller units of vegetation are characterized in selected study areas. A comparison of these plant communities and call count data is shown for each locality.

Imhof, T. A. 1976. Alabama birds, 2nd ed. The University of Alabama Press, Tuscaloosa. 445 pp.

A description of the habitats, breeding seasons, migration areas, and an official checklist of Alabama birds is given. Includes information on shorebirds, wading birds, diving birds, offshore birds, and migratory waterfowl.

Johnson, P. G. 1979. Wading birds of coastal Alabama. Pages 225-248 *in* H. A. Loyacano, Jr., and J. P. Smith, eds. Symposium on the natural

resources of the Mobile Estuary, Alabama. Alabama Coastal Area Board, Daphne.

A discussion of the status and location of nesting colonies of coastal Alabama. The discussion includes separate sections on the natural history of the species surveyed. Contains color photographs of some of the colonies and a map of their locations.

Kale, H. W., II. 1978. Rare and endangered biota of Florida. Vol. 2: Birds. University Presses of Florida, Gainesville. 121 pp.

A discussion of the rare and endangered birds of Florida, their habitats and status.

O'Neil, P. E., and M. F. Mettee. 1982. Alabama coastal region ecological characterization. Vol. 2. A synthesis of environmental data. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-82/42. 346 pp.

The report is divided into two sections. The first section contains a detailed description of the geology and geography, hydrology, climate, plant and animal life, and threatened and endangered species of coastal Alabama. The second section presents a conceptual model and supporting text on four natural ecosystems (freshwater, upland terrestrial, estuarine, and Continental Shelf) and two manipulated (urban-industrial and agricultural) systems in Mobile and Baldwin Counties. Also included are individual models for the estuarine ecosystem and one of its components, the marsh.

Portnoy, J. W. 1977. Nesting colonies of seabirds and wading birds: coastal Louisiana, Mississippi, and Alabama. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-77/07.

A survey of 168 colonies of seabirds and wading birds along the Louisiana-Mississippi-Alabama coast was conducted from February to August 1976. Colonies were mapped on 1:250,000 scale USGS maps and cataloged by latitude and longitude coordinates. Abundance was tabulated by species, salinity, and habitat type. Nesting chronology of the common breeders was outlined.

Aerial and ground-based inventory techniques were used. Reliabililty of the various census and sampling methods for the 26 species in diverse nesting situations was evaluated. Aerial photography produced accurate censuses of incubating great egrets (Casmerodius albus), sandwich terns (Sterna sandvicensis), and royal terns (Sterna maxima [Thalasseus maximus]). Randomly placed 2-m wide belt transects yielded representative samples of active heron, egret, and ibis nests in large shrub colonies.

Portnoy, J. W. 1978. North Gulf of Mexico coastal waterbird colonies: changes in breeding abundance and distribution from 1976 to 1978. (unpubl. photocopy). 46 pp.

In April and June 1978 the Gulf of Mexico coast from Sabine Pass to Mobile Bay was surveyed by fixed-wing aircraft to locate waterbird colonies and photographically census incubating great egrets and black skimmers. Techniques and timing of aerial surveys and photography are discussed. Colony locations are mapped and, together with census results and breeding distribution, are compared with survey results from 1976.

U.S. Army Corps of Engineers. 1983. Mississippi Sound and Adjacent Areas. U.S. Army Corps of Engineers, Mobile District, Mobile. 275 pp.

A detailed environmental and socioeconomic analysis of the study area for use in evaluating various approaches to dredging and disposal of dredging spoils. An initial reconnaissance report was published in March 1979. A final report will be issued at a later date.

U.S. Fish and Wildlife Service. 1982. Central Gulf Coast Wetlands, Migratory Bird Habitat Preservation Program, Category 9. Atlanta, GA. 103 pp.

This publication identifies 14 coastal wetland areas in Alabama, Louisiana and Mississippi selected for preservation as important waterfowl habitats. Included in the document are 14 maps of the areas selected and a discussion on each unit.

Grass Beds

Stout, J. P., and M. J. Lelong. 1981. Wetland habitats of the Alabama coastal area. Ala. Coast. Area Board Tech. Publ. CAB-81-01. 27 pp.

This inventory provides a baseline of extent and composition of wetland habitats as natural resources of the Alabama Coastal Zone. The inventory includes all areas within the Coastal Zone (10-ft contour south of the Battleship Parkway (Hwy 90)).

Habitats examined include swamps (forested wetlands), marshes, and submersed grassbeds in coastal waters. Both black and white and color infra-red photography taken in September and October, 1979, were used to delineate habitat boundaries and to calculate acreage of each habitat. Plant community descriptions of all habitat types and locations of submersed grassbeds were determined in 1980 by extensive field surveys.

Wetland distributions and types are portrayed on U.S. Geological Survey topographic maps. Eighteen 7 1/2' quadrangles (1:24,000) and two 15' quadrangles (1:64,000) were used to obtain coverage of the area.

Stout, J. P., M. J. Lelong, H. M. Dowling, and M. T. Powers. 1982. Wetland habitats of the Alabama Coastal Zone. Part III: An inventory of wetland habitats of the Mobile-Tensaw River Delta: Ala. Coast. Area Board, CAB Tech. Report 81-49A 25p.

A continuation of wetland habitat mapping. The inventory includes those areas north of the Battleship Parkway (Hwy 90).

Benson, N. G., editor. 1982. Life history requirements of selected finfish and shellfish in Mississippi Sound and adjacent areas. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-81/51. 97 pp.

The published and unpublished literature on spawning, nursery, and migratory requirements of 41 finfish and shellfish species in Mississippi Sound, Mobile Bay, and adjacent waters. Species were selected because of high abundance or significant value for recreational or commercial fishing. The primary ecological parameters considered were temperature, salinity, depth, substrate, turbidity, and current. Available data on habitats, distribution in water column (pelagic, demersal), and diurnal behavior are treated. The ecological role of each species in the ecosystem is discussed.

Christmas, J. Y., and D. J. Etzold. 1977. The shrimp fishery of the Gulf of Mexico, United States: a regional management plan. Gulf Coast Res. Lab. Tech. Rep. Ser. 2. 128 pp.

The shrimp fishery is summarized and includes the complexity of the fishery and species involved; biology, including life history and habitat considerations; descriptions of the industry; economic and sociological considerations; and the status of the resource and yields.

Eckmayer, W. J. 1979. The oyster fishery in Mobile Bay, Alabama. Pages 189-200 in H. A. Loyacano, Jr., and J. P. Smith, eds. Symposium on the natural resources of the Mobile Estuary, Alabama. Alabama Coastal Area Board, Daphne.

This is a discussion of the factors affecting oyster production in Mobile Bay, including both natural factors, such as salinity, oxygen, and predators, and manmade factors, such as dredging and pollution. Contains a small scale (1" = 5.5 mi) map of the oyster reefs in lower Mobile Bay.

May, E. B. 1971. A survey of the oyster and oyster shell resources of Alabama. Ala. Mar. Resour. Bull. 4. 53 pp.

The public oyster reefs and buried shell deposits in Alabama were mapped and inventoried. Second-order survey was used to establish triangulation stations used for mapping. Environmental and socioeconomic factors which influence oyster production are discussed. The locations of the living oyster beds and the oyster shell deposits are mapped on detailed, colored 1:24,000 scale maps.

Swingle, H. A. 1971. Biology of Alabama estuarine areas. Cooperative Gulf of Mexico estuarine inventory. Ala. Mar. Resour. Bull. 5. 123 pp.

Stations were sampled monthly from January 1968 through March 1969. A total of 162 species of fishes and 44 species of invertebrates were collected from the estuarine waters of Alabama. Seventy-six species of fishes were documented from other sources. The areal and seasonal

distribution of the species are discussed. Also presented are data on the density of oysters on the public reefs and historical fisheries statistics.

Swingle, H. A. 1977. Coastal fishery resources of Alabama. Ala. Mar. Resour. Bull. 12:31-58.

A description is given of the fishing resources of Alabama, including ownership of resources, recreational fishing, commercial fishing, major species (finfish, shellfish, and potential fisheries), and factors affecting coastal fishery resources. Tabular data (as recent as 1975) includes landings for commercial and recreational fisheries, seafood wholesale and retail data, numbers of boats, etc.

Finfish of Coastal Alabama

Benson, N. G., editor. 1982. Life history requirements of selected finfish and shellfish in Mississippi Sound and adjacent areas. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-81/51. 97 pp.

The published and unpublished literature on spawning, nursery, and migratory requirements of 41 finfish and shellfish species in Mississippi Sound, Mobile Bay, and adjacent waters. Species were selected because of high abundance or significant value for recreational or commercial fishing. The primary ecological parameters considered were temperature, salinity, depth, substrate, turbidity, and current. Available data on habitats, distribution in water column (pelagic, demersal), and diurnal behavior are treated. The ecological role of each species in the ecosystem is discussed.

Christmas, J. Y., G. Gunter, E. C. Whatley. 1960. Fishes taken in the menhaden fishery of Alabama, Mississippi, and eastern Louisiana. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. No. 339. 10 pp.

A study was made of fishes other than menhaden taken by menhaden purse seiners in waters around the mouth of the Mississippi River and in Mississippi Sound during the 1958 and 1959 seasons. In numbers of fish, more than 97% of the sampled catch were menhaden.

Friend, J. H., M. Lyon, N. Garrett, J. L. Borom, J. Ferguson, and G. C. Lloyd. 1981. Alabama coastal region ecological characterization: Volume 3: A socioeconomic study. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-81/41. 367 pp.

The purpose of the socioeconomic characterization study is to compile and synthesize information from existing sources concerning the social, demographic, and economic factors in the Alabama Coastal Region. This report is one of a series of characterizations of coastal ecosystems produced by the U.S. Fish and Wildlife Service to describe the relationships between human population growth and the availability of natural resources in the Nation's coastal areas.

Loesch, H. C. 1976c. Observations on mendahen (Brevoortia) recruitment and growth in Mobile Bay, Alabama. Proc. La. Acad. Sci. 39:35-42.

Menhaden, Brevoortia patronus Goode, were sampled at monthly intervals by 12 bay stations and 11 nearshore stations in Mobile Bay by shrimp trawl and drag net from June 1954 to July 1955. Estimates of total length of growth during various times of the year are given. An equation is developed by fitting the data to a linear regression on log scale.

Swingle, H. A. 1971. Biology of Alabama estuarine areas. Cooperative Gulf of Mexico estuarine inventory. Ala. Mar. Resour. Bull. 5. 123 pp.

Twenty trawl stations, five seine stations, and four plankton stations were sampled monthly from January 1968 through March 1969. A total of 162 species of fishes and 44 species of invertebrates were collected from the estuarine waters of Alabama. Seventy-six species of fishes were documented from other sources. The areal and seasonal distribution of the species are discussed. Also presented are data on the density of oysters on the public reefs and historical fisheries statistics.

Swingle, H. A. 1975. Fishes of the coastal area of Alabama. Pages 8-28 in Fishes, birds, and mammals of the coastal area of Alabama. Alabama Department of Conservation and Natural Resources, Montgomery.

Swingle, H. A. 1977. Coastal fishery resources of Alabama. Ala. Mar. Resour. Bull. 12:31-58.

A description is given of the fishing resources of Alabama, including ownership of resources, recreational fishing, commercial fishing, major species (finfish, shellfish, and potential fisheries), and factors affecting coastal fishery resources. Tabular data (as recent as 1975) includes landings for commercial and recreational fisheries, seafood wholesale and retail data, numbers of boats, etc.

Swingle, H. A., and D. G. Bland. 1974b. A study of the fishes of the coastal water courses of Alabama. Ala. Mar. Resour. Bull. 10:17-102.

Trawl or seine samples were collected monthly at 23 stations between December 1970 and May 1972 within the brackish water zone of the coastal watercourses of Alabama. Water salinity, temperature, and dissolved oxygen values are presented and are correlated to some extent with species abundance and diversity. The species composition of altered and unaltered watercourses and the species composition of estuarine waters are discussed.

Swingle, W. E. 1976. Analysis of commercial fisheries catch data for Alabama. Ala. Mar. Resour. Bull. 11:26-50.

This paper discusses the changes in the number of seafood plants, number of persons employed in them and the value of seafood processed between 1964 and 1971. Also discussed is the amount of commercial seafood

landed, the value of the seafood landed, and the number of fishermen employed between 1964 and 1971.

Wade, C. W. 1977. Survey of the Alabama marine recreational fishery. Ala. Mar. Resour. Bull. 12:1-22.

Contains data on catch per unit effort and quantities and locations of sportfishing catches.

SOCIOECONOMICS

INTRODUCTION

The socioeconomic elements mapped and discussed include man-made features and natural areas having either ecological or economic significance, such as wildlife refuges, State park recreational areas, barrier islands, and historical or archaeological sites. Man-made features include solid waste landfills, navigation channels, and dredge-spoil disposal areas. Many of these areas are subject to Federal, state, or local regulations for land use within their boundaries.

LAND USE AND LAND COVER

Four categories of land use are mapped on the atlas sheets: forested, urban, agricultural, and uncategorized. Forested land was considered as any area with greater than 30% canopy cover. Forest land may be used for timber production, as a game refuge, or any other use which does not alter the woodland nature. Some mature old fields which have reverted to woodland are included in the forested category.

The urban category includes residential, commercial, and industrial land uses and includes major transportation facilities such as large highway interchanges and airports. The agricultural category includes areas currently under cultivation or prepared for cultivation, pasture, and associated buildings. It does not include timber plantations.

The uncategorized classification is essentially a residual category. A cross check with the Biological Resources maps in this atlas will show, however, that more than 90% of this category is wetland, as defined by the U.S. Fish and Wildlife Service (Cowardin et al. 1979).

All categories mapped were derived by aerial photo interpretation. The photos were taken by the National Aeronautics and Space Administration (NASA) and were color infrared at a scale of 1:62,500, dated 1979. The minimum mapped unit is approximately 10 acres. Mobile and Baldwin counties were mapped in 1972 by the U.S. Geological Survey using criteria developed by Anderson et al. (1976). Very general land use maps have also been produced by local or regional Alabama agencies.

The following information on the two coastal counties is included to convey a general understanding of land cover and use in the area. The data are from a wide variety of sources as reported in the U.S. Fish and Wildlife

Service publication Alabama Coastal Region Ecological Characterization: A Socioeconomic Study (Friend et al. 1981). That publication contains a great deal of detailed data and mapped information.

Mobile County has a land surface area of 321,408 ha (793,600 acres) and Baldwin County, the largest county in Alabama, has 427,835 ha (1,056,400 acres). In 1975, the land usage in these two coastal counties was in the following percentages: 48% in forest; 19% in agriculture, 3% in transportation, communications and utilities; 2% in residential; 1% in industrial and commercial; and 27% undeveloped. Table 8 presents a summary of land use acreage in Mobile and Baldwin Counties. Mobile County is predominantly urban and industrial, while Baldwin is primarily rural and agricultural with the exception of urban centers along the eastern shore of Mobile Bay. The two-county population in 1980 was 442,819 persons.

The major agricultural products of coastal Alabama include soybeans, nursery products, vegetables, cattle, and calves. In 1978, cash receipts from farm marketing were $106.9 million. In 1979 the total dollar amount decreased slightly due to damage by Hurricane Frederic in September of that year.

The majority of forests in the two counties are pine species (loblolly and shortleaf) used for pulpwood for the manufacture of paper products. Next in importance is saw timber and the harvesting of veneer logs for plywood.

Table 8. 1975 land use by county in acres and percent of total acreage (South Alabama Regional Planning Commission 1977).

Land use	Mobile County		Baldwin County	
	Acres	Percent	Acres	Percent
Residential	35,151	4.4	9,651	0.9
Commercial	4,002	0.5	1,159	0.1
Industrial	4,808	0.6	568	0.1
Transportation, communications, and utilities	38,571	4.9	19,927	1.9
Total urban	82,532	10.4	31,305	3.0
Public and semipublic	13,571	1.7	3,580	0.7
Agriculture	136,534	17.2	216,919	20.5
Forestry	389,401	49.1	503,212	47.6
Wetlands	78,198	9.8	174,082	16.5
Water	22,343	2.8	46,462	4.4
Undeveloped dry	66,887	8.4	74,874	7.1
Other open	4,401	0.6	1,948	0.2
TOTAL	793,600	100.0	1,056,382	100.0

In 1978, cash receipts from sales of raw stumpage products were $3.2 million for Mobile County and $12.5 million for Baldwin County.

MARINE AND ESTUARINE SANCTUARIES

While there are no officially designated marine or estuarine santuaries located in the coastal counties of Alabama, several areas are being protected and preserved by such agencies as the U.S. Fish and Wildlife Service under wildlife management programs. The major programs dealing with estuarine sanctuaries recently have been, at the Federal level, under the Coastal Zone Management Act (CZMA) of 1972 (Public Law 92-583) and at the State level, under the Alabama Coastal Area Act of 1976 (Act No. 534).

In late 1982, the State of Alabama initiated an application to the National Oceanic and Atmospheric Administration (NOAA), of the U.S. Department of Commerce under the guidelines of the Coastal Zone Management Act of 1972, for the establishment of an estuarine sanctuary in the vicinity of Weeks Bay (Pensacola quadrangle) in Baldwin County. Approximately 142 ha (350 acres) of land had been purchased by the Nature Conservancy at that time to be part of the sanctuary if and when it is actually established. Negotiations are ongoing to add more land to that total in areas both east and west of the Fish River bridge (Pensacola quadrangle) immediately north of Weeks Bay. Total acreage is expected to be approximately 800 acres. Negotiations between the State of Alabama and NOAA are ongoing at this time (Thurman Shores, Alabama Department of Economic and Community Affairs, Montgomery, AL, 23 May 1984; pers. comm.).

NATIONAL WILDLIFE REFUGES

On 9 June 1980, Congress passed Public Law 96-267, which authorized the purchase of 4047 ha (10,000 acres) of land in Mobile and Baldwin Counties to be set aside as the Bon Secour National Wildlife Refuge. In fiscal year 1982 approximately $3 million were available for acquisition (William Swanson, U.S. Fish and Wildlife Service, Atlanta, GA, 16 February 1982; pers. comm.). Additional land purchases to complete acquisition will depend upon future appropriations from the U.S. Congress. The refuge consists of four units: Little Dauphin Island (Biloxi quadrangle), Little Point Clear, Perdue, and Skunk Bayou (Pensacola quadrangle). The following information is taken primarily from Bon Secour National Wildlife Refuge: A Proposal (U.S. Fish and Wildlife Service 1980).

These ecologically fragile areas provide a buffer between the open ocean and the highly productive and economically important brackish estuaries of Mobile Bay. The estuaries are spawning and nursery areas for commercially and recreationally important species, including many forms of crustaceans, mollusks, fish, and birds.

For over 90 species of migratory birds, the refuge is the staging area and last major landfall before their trans-gulf migration, as well as the first major landfall upon their return. The area also boasts about 125 wintering, 100 resident, and 40 nonresident species of birds. During a peak

year, over 2 million individual birds may be in the refuge area at one time (U.S. Fish and Wildlife Service 1980).

Five species of sea turtles listed as threatened or endangered may use the offshore water adjacent to the area; but are not currently known to use the beaches for nesting. However, the last known loggerhead turtle (Caretta caretta) nesting site in Alabama was located on the Ft. Morgan Peninsula (Pensacola quadrangle) (U.S. Fish and Wildlife Service 1980). Five other Federally listed Endangered and Threatened species may occur within the refuge. Prehistoric Indian sites of potential archaeological value are also found in the area (Alabama Historical Commission 1978).

STATE PARKS

The Alabama State Parks system had its beginning in 1927, when the State legislature passed the State Land Act, vesting the State's interest in parks in the Alabama Commission of Forestry and placing all State land under the Commission's administration. In 1933, the Civilian Conservation Corps, cooperating with the State of Alabama, under the supervision of the National Park Service, began the development of state parks. This program generated such interest in recreational development that by the fall of 1935 Alabama had placed 15 park areas under consideration for development. Total land area of the 22 state parks in Alabama in 1935 was 9,415 ha (23,265 acres). Individual parks ranged from 2,056 ha (5,080 acres) to a small historic site of 3 ha (7 acres). It was during this period that the lands for Gulf State Park (Pensacola quadrangle) in Baldwin County were acquired.

In March 1939 the Alabama State Legislature passed an act creating the Alabama Department of Conservation, as it is known today. A part of this new department was the Division of Parks, Monuments, and Historical Sites that was given jurisdiction over all state park lands. With the creation of this new department came the decision to select 5 of the then-existing 23 parks and carry out extensive development and promotion. Gulf State Park was one of the five chosen; its official opening date was 20 May 1939.

In 1948 two small park areas were constructed as additions to Gulf State Park in Baldwin County. These were Romar Beach and Alabama Point (Pensacola quadrangle), located on the coastal highway that runs through Gulf State Park to Alabama Point. These two park areas, with a total of 3 mi of beach-front, are important access areas to gulf waters and enable Gulf State Park visitors to reach gulf waters without crossing private property (Jacocks 1977).

Gulf State Park now offers one of the widest ranges of activities found in any of the Alabama State Parks. Located on 2428 ha (6,000 acres) of land, activities include picnicking, swimming, boating, fishing, hiking, tennis, and bicycling. Available accommodations range from primitive to improved campsites and from family cottages to a resort inn. Facilities also include a convention facility and an 18-hole championship golf course. The state-owned lands have 5 km (3 mi) of beach frontage and a 251-m, (825-ft) fishing pier extending into the Gulf of Mexico. The resort inn, convention complex, and restaurant are operated by ARASERV, Inc., under a 1973 agreement

authorizing the operation of certain state-owned facilities by private corporations (Alabama Department of Conservation and Natural Resources, n.d.).

Meaher State Park (Bay Minette quadrangle) is located on the Tensaw River and Mobile Bay and contains 537 ha (1,327 acres). The basic facilities are boat launching ramps and piers for boating and fishing (Friend et al. 1981).

Additional information is available by contacting:

Alabama Department of Conservation and Natural Resources
Alabama State Parks Division
64 North Union Street
Administration Building
Montgomery, AL 36130
(205) 261-3334.

In May 1983, an in-state toll-free number for information was made available. This number is 1-800-ALA-PARK (251-7275).

STATE WILDLIFE MANAGEMENT AREAS

Of the 28 State Wildlife Management Areas and Refuges in Alabama, only one, the Frank W. and Rob M. Boykin Wildlife Management Area (Citronelle quadrangle) is located in the Mobile and Baldwin County study area. Most of the Boykin Wildlife Management Area is located in adjacent Washington County, with less than a sixth of the total area of 23,350 acres located in Mobile County.

Hunting within the area is controlled and permits are required. These permits are issued by the Management Area Headquarters on either a seasonal or daily basis, depending upon type of game hunted and weapon used. Gun, primitive weapon, and bow-and-arrow hunting all have designated seasons and regulations, although bag limits are the same. Game animals hunted include deer, raccoon, opossum, turkey, quail, squirrel, and rabbit (Alabama Department of Conservation and Natural Resources 1981).

Additional information is available by contacting:

Area Manager
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WILD AND SCENIC RIVERS

In the State of Alabama, six rivers have been authorized for study under the National Wild and Scenic Rivers Act of 1968 (PL 90-452) as amended. These included the Styx, Blackwater, and Perdido Rivers (Pensacola and Bay Minette quadrangles) and a short section of Soldier Creek in Baldwin County, and the Escatawpa River (Mobile quadrangle) and a portion of one of its tributaries, Brushy Creek, in Mobile County (U.S. Army Corps of Engineers 1981).

The Styx, Blackwater, and Perdido Rivers have not yet been studied; a 5-km (3-mi) section of Soldier Creek was studied, but subsequently deauthorized. The Escatawpa River and about 11 km (7 mi) of Brushy Creek, from Scarborough Creek to its confluence with the Escatawpa, were studied by the National Park Service for designation as Wild and Scenic Rivers. Although the river was found to be eligible for inclusion as a Wild and Scenic River, the National Park Service recommended it not be included due to opposition from private waterfront owners (National Park Service 1983).

NATIONAL NATURAL LANDMARKS

The drainage area of the Mobile River basin is 113,000 km^2 (43,629 mi^2) and includes areas in Alabama, Georgia, Mississippi, and Tennessee. The basin is the largest gulf drainage east of the Mississippi River and has extensive wetlands north of its confluence with Mobile Bay. The Mobile-Tensaw River Bottomlands National Natural Landmark (Mobile and Bay Minette quadrangles) was designated in 1974 to acknowledge the area as one of the most important wetlands in the nation (Frank Ugolini, National Park Service, Washington, D.C., 12 November 1982, pers. comm.). Although the designation implies National recognition of the area's importance, ownership of the lands remains with over 130 private and public landowners. The following information is taken primarily from the Natural Landmark Brief for this area (U.S. National Park Service 1974).

The area is essentially a large flood plain originating near the confluence of the Alabama and Tombigbee Rivers. The northern reaches have a network of streams and lakes with low forested islands and mesic (moderately moist) sites on the higher elevations merging into open, brackish marshes to the south. The southern boundary of the delta is northern Mobile Bay. This delta is unusual in that it is bounded on either side by relatively high, distinct upland terraces.

The mesic sites contain ash, magnolia, and holly, while the lower, wetter sites are primarily water tupelo and cypress. Also common are red maple, mulberry, and black willow along the watercourses. The bottomland hardwood forest in the northern portion of the tract is dominated by sweet gum, water oak, ash, hackberry, and cottonwood. Herbaceous plants include spider lily, arrowheads, lizard's tail, grasses, and sedges. The open aquatic habitats contain elodea, tapegrass, water lily, arrow-arom, and cattails.

The rivers comprising the Mobile Delta contain several species of rare fishes, including the blue sucker (Cycleptus elongatus) and Atlantic sturgeon (Acipenser oxyrhynchus). The Mobile Delta is one of the few large habitats for the Federally endangered American alligator (Alligator mississippiensis) between Louisiana and Florida.

Other reptiles in the area include Pseudemys alabamensis, the Alabama red-bellied turtle, and Graptemys nigrinoda delticola, the southern black-knobbed sawback turtle, which is endemic to the delta. The concentration of birds, especially waterfowl, in the area is tremendous, with such rare species as the mottled duck (Anas fulvigula maculosa), the Mississippi kite (Ictinia mississippiensis), and the swallow-tailed kite (Elanoides

forficatus). The only known populations in Alabama of Florida black bears (*Ursus americanus floridanus*) occur within the delta, the northern black bear (*Ursus americanus*) apparently having been extirpated in the State (Boschung 1976). Common mammals in the delta floodplain include beaver, raccoon, river otter, and deer.

The National Natural Landmark area is used mostly for hunting, fishing, and boating. Although some commercial logging is done, it is limited because of the area's inaccessibility. New techniques for logging may, however, result in the area becoming more disrupted in the future. The rivers of the Mobile Delta drain a great deal of farmland and consequently carry a heavy load of silt and agricultural chemicals. Additional chemicals are discharged into the rivers from the industrial areas adjacent to Mobile.

NATIONAL AUDUBON SOCIETY SANCTUARY

The National Audubon Society leases approximately 64 ha (159 acres) of land on Dauphin Island (Biloxi quadrangle) from the Dauphin Island Park and Beach Board. The current 10/year lease runs from 1980 to 1990. The facilities currently consist of an entrance, parking lot, and several nature trails. A boardwalk over the dunes is proposed. The land includes a beach-dune complex with high dunes, a gum swamp, a large freshwater lake, and sandy pine woods (Friend et al. 1981). Like the Bon Secour National Wildlife Refuge, the area is important to both resident and migratory species of birds. In a 48-hour period in 1979, 176 species of birds were identified on the sanctuary (Myrt Jones, National Audubon Society, Mobile, AL; 17 March 1982; pers. comm.).

INTENSIVELY USED RECREATIONAL BEACHES

The beaches of Alabama are a recreational resource important to the tourist industry of Mobile and Baldwin Counties. These counties have about 80 km (50 mi) of beaches on the Gulf of Mexico and another 103 km (64 mi) along the bays (Mobile, Weeks, Perdido, etc.) and Mississippi Sound (South Alabama Regional Planning Commission and J. H. Friend, Inc. 1971).

Water off the wide white-sand beaches fronting the open ocean is generally clear. While the bay and sound areas are economically important, especially in seafood production, they tend to be muddier and not as attractive as the white-sand gulf beaches for such beach activities as swimming, wading, and sunbathing.

The principal gulf beaches are Dauphin Island (Biloxi quadrangle) in Mobile County, which is 24 km (15 mi) long, and the southern border of Baldwin County from Mobile Point (Pensacola quadrangle) to the Florida state line, which comprises 51 km (32 mi) of ocean beach. Most of the gulf shoreline is privately owned, although the city of Gulf Shores makes available 458 m (1500 ft) of beach and the state maintains 5 km (3 mi) of beach for public use at Gulf Shores State Park. In Mobile County, there is 0.8 km (0.5 mi) of public-use beach on Dauphin Island (Friend et al.1981).

It was estimated (Table 9) that 2.5 million tourists visited Mobile, Baldwin, and Escambia Counties in 1970 and that the number was likely to increase 76% to 4.4 million in 1980 (South Alabama Regional Planning Commission and J. H. Friend, Inc. 1971, Gulf Research Associates 1981).

Although the Parks Division of the Alabama Department of Conservation and Natural Resources (1981) estimated that 3.4 million tourists visited Gulf State Park in 1978 and 3.2 million in 1979, these estimates may be high. Traffic volume analysis on the major highways in the Gulf Shores area by Gulf Research Associates showed a total of approximately 2.0 million recreational visitors per year (Friend et al. 1981).

Table 10 shows the annual vehicle flow on the major highways leading to two intensively used recreational beaches, Dauphin Island and the Gulf Shores area. Traffic increased by approximately 75% to 200% in these areas between 1965 and 1979. The increase in recreational visitors before Hurricane Frederic in 1979 is shown in Table 11. Hurricane Frederic interrupted the expansion of the tourist trade by disrupting the aesthetics of the coast, destroying many tourist facilities and, more directly, destroying the causeway connecting Dauphin Island to the mainland. Although a ferry carried some tourists to the island, tourist flow was hampered until July 1982, when the causeway was reopened.

CHARTER BOAT AND HEAD BOAT SERVICE

Although the commercial fishing industry of the United States has become relatively less economically important worldwide, the sport fishing industry has increased in volume of catch to the point where the sport catch exceeds the commercial catch for some species. In Alabama, the saltwater sport fish landings in 1975 were only 53% of the commercial landings in total weight, although the sport landings exceeded the commercial landings for 15 species (Wade 1977). In response to the increasing demand for sport fishing opportunities, the number of facilities for charter boats and head boats has been increasing in Alabama (Chermock 1974). The charter boat-head boat industry in Alabama was estimated by Swingle (1970) to have provided 39,480 fishing trips at a cost of $730,350 in 1969.

Charter boats generally involve small groups of people (6 to 8), and troll for larger game fish, such as Spanish mackerel (Scomberomorus maculatus), king mackerel (Scomberomorus cavalla), and crevalle jack (Caranx hippos). Head boats carry large numbers of people and fish off the bottom, rather than troll. The head or party boats carrying a larger group of people take advantage of the concentrations of fish on artificial fishing reefs, where the main catch is amberjack (Seriola dumerili) and red snapper (Lutjanus campechanus) (Chermock 1974, Friend et al. 1981). Table 12 shows the composition of catch from charter boats out of Orange Beach (Pensacola quadrangle).

There are approximately 27 charter and head boat operations in Alabama waters. The general locations of facilities/boats are shown in Table 13. About 17 of the charter and head boats are now located in Baldwin County, while 10 are in Mobile County. The largest concentration is at Orange Beach,

Table 9. Number of tourist trips, average length of stay, average party size, and number of tourists[a] visiting Mobile, Baldwin, and Escambia Counties by automobile, 1970, 1980 (Friend et al. 1981).

Tourist item	1970	1980
Number of tourist trips (1,000's)		
Terminal	218	328
Transient	942	1,422
Business	416	616
Total	1,576	2,366
Average length of stay in the area		
Terminal	2.1 days	2.1 days
Transient	0.5 hours	0.5 hours
Business	2.0 days	2.0 days
Average party size		
Terminal	3.0	3.3[b]
Transient	3.0	3.3[b]
Business	1.0	1.5[b]
Number of tourists (1,000's)		
Terminal	654	1,082
Transient[c]	1,413	2,347
Business	416	924
Total	2,483	4,353

[a]Tourist = traveler going 100 miles or more from his county of residence to engage in pleasure-oriented activities; terminal tourist = one who has arrived at his primary destination; transient tourist = one who is traveling to or from his primary destination; business tourist = one traveling on business, but participating in pleasure-oriented activity not directly related to work.

[b]Estimated by Gulf Research Associates, Inc. based on data from Auburn University's Travel and Tourism in Alabama 1979 study.

[c]Assumes 50% of transient tourists traveling through the area actually stop (South Alabama Regional Planning Commission and John H. Friend, Inc. 1971).

Table 10. Average daily two-way traffic volume (number of vehicles) on highways providing access to the Alabama coastal region's major recreational beach areas, 1965, 1970, 1977, 1978, 1979 (Friend et al. 1981).

Year	Hwy. 163, immediately north of the Dauphin Island bridge	Hwy. 59, just north of the city of Gulf Shores	Gulf Shores Beach Hwy. 182, just west of the Florida State line
Annual average daily two-way			
1965	1,690	3,060	700
1970	2,440	4,720	850
1977	3,110	7,510	1,770
1978	3,220	8,430	2,290
1979[a]	2,920	8,850	2,180
Annual percent change			
1965-70	7.6	9.1	4.0
1970-79	2.0	7.2	11.0
1965-79	4.0	7.9	8.5

[a] Assuming "pre-hurricane" conditions.

Table 11. Number of recreational visitors to Dauphin Island, 1965, 1970, 1977, 1978, 1979 (Friend et al. 1981).

Year	Annual average daily one-way traffic	Percent recreational	Annual recreational auto trips	Average persons per auto	Number of recreational visitors
1965	845	58	178,850	3	536,550
1970	1,220	58	258,420	3	775,260
1977	1,555	58	329,230	3	987,690
1978	1,610	58	340,910	3	1,022,730
1979[a]	1,460	58	309,155	3	927,465

[a] Assuming "pre-hurricane" conditions.

Table 12. Selected characteristics of catch by species for charter boat operators, Orange Beach, Alabama, 1975 (Friend et al. 1981 adapted from Wade 1977).

Species	Average catch per boat	Distribution of catch (%)	Average catch per man-hour
Amberjack	6,052	38.0%	0.83
Cobia	252	1.6%	0.03
Dolphin	274	1.7%	0.04
Groupers	175	0.1%	0.02
Crevalle jack	226	1.4%	0.03
King mackerel	3,477	21.9%	0.48
Little tunny	2,161	13.6%	0.30
Snapper	2,631	16.5%	0.36
Spanish mackerel	659	4.1%	0.09
Total	15,907	98.9%	

Table 13. Charter boats and head boats operating in Alabama (Ronald L. Schmeid, National Marine Fisheries Service, St. Petersburg, FL; 3 June 1981, pers. comm.).

Location	Number charter boats	Number head boats
Baldwin County		
Perdido Beach(1)[a]	1	0
Orange Beach(1)	14	1
Point Clear(1)	1	0
Total	16	1
Mobile County		
Mobile(2)	2	0
Dauphin Island(3)	3	2
Bayou La Batre(3)	0	3
Total	5	5

[a]Quad sheet: (1) Pensacola, (2) Mobile, (3) Biloxi.

while the majority in Mobile County are at Dauphin Island (Ronald L. Schmeid, National Marine Fisheries Service, St. Petersburg, FL; 1981; pers. comm.). According to Friend et al. (1981), prior to Hurricane Frederic 70% of the charter and head boats in Alabama were in Baldwin County. As a result of the destruction from the hurricane, particularly the loss of the Dauphin Island Causeway (Biloxi quadrangle), 90% of the charter and head boats were located in Baldwin County immediately after the hurricane. In terms of size, most charter and head boats are between 8.5 and 17.7 m (28 to 58 ft) (Alabama Sea Grant Advisory Service 1978).

PERMITTED ARTIFICIAL FISHING REEFS

Most of the substrate off the Alabama coast is composed of hard to soft mud and sand, with little cover, such as natural reefs and obstructions, to provide habitat for encrusting invertebrates and forage fish. An attempt to provide such cover and thereby increase game fish populations was begun in the 1950s by the Alabama Department of Conservation and Natural Resources. The Department submerged groups of automobile bodies in waters, usually at 18- to 27-m (60-to 90-ft) depths. In the 1960's and 1970's more obstructions were sunk, including such things as liberty ships, bridge materials, lifeboats, pipes and culverts, and barges. Table 14 shows the compositions, ages, and depths of the permitted reefs (Alabama Department of Conservation and Natural Resources 1981; U.S. Fish and Wildlife Service 1981).

Game fishes attracted to these artificial reefs include both bottom-dwelling and midwater species. Bottom-dwelling species inhabiting the structures are primarily snappers (*Lutjanus* spp.) and grouper (*Epinephelus* spp.). Red drum (*Sciaenops ocellatus*) are found on the shallower (18- to 23-m or 60- to 75-ft) reefs, especially in the winter. Pelagic midwater game fishes are attracted to concentrations of forage fish swarming around the reefs. The former include primarily greater amberjack (*Seriola dumerili*), crevalle jack (*Caranx hippos*), cobia (*Rachycentron canadum*), little tunny (*Euthynnus alletteratus*) and mackerels (*Scomberomorus* spp.).

The prevailing water currents on the reefs situated off Baldwin County are from the east (Florida), which gives these reefs a high affinity for the blue water-sand bottom Floridian fauna. These westward currents are diverted offshore by the waters flowing out of Mobile Bay. Reefs to the west, located south of Dauphin Island, are subjected to lower salinities than those to the east and their fauna is more estuarine in nature. The deeper reefs are less subject to salinity and temperature fluctuations and their fauna has more tropical affinities than the inshore reefs (Bennie Rohr, National Marine Fisheries Service, Pascagoula, MS; 30 November 1982; pers. comm.).

PUBLIC FISHING PIERS, PUBLIC ACCESS AREAS AND MARINAS

There are six public fishing piers in Mobile and Baldwin Counties. The piers on the gulf are located at Gulf State Park (Pensacola quadrangle) and Young's-by-the-sea (Pensacola quadrangle) in Baldwin County and at Bienville Beach, Dauphin Island (Biloxi quadrangle) in Mobile County. The Fairhope Municipal Pier (Bay Minette quadrangle), May Day Pier (Bay Minette quadrangle near Daphne) and Autrey's Pier (Mobile quadrangle on Battleship Parkway)

Table 14. Permitted artificial fishing reefs (Alabama Department of Conservation and Natural Resources 1981).

Name[a] designation	Depth (ft)	Depth (m)	Compass readings (mi) Sand Is. Light	Compass readings (mi) Perdio Pass Sea Buoy	Year	Material composition
Tug Boat	64	20	102° (19.0)	212° (19.5)	1976	105 ft wood tugboat
Dry Dock	72	22	194° (10.6)	241° (32.1)	1957	350 ft drydock
Tulsa	84	26	190° (11.0)	240° (32.5)	Unknown	Unknown wreck
Anderson	82	25	187° (10.3)	240° (30.9)	1974	Liberty ship, 3-30 ft lifeboats
Edwards	84	26	190° (13.8)	236° (34.4)	1974	Liberty Ship
Buffalo Barge #2	66	20	116° (12.3)	223° (17.7)	1972	300 ft Barge
Buffalo Barge #1	54	16	115° (13.0)	231° (17.2)	1972	300 ft Barge
Ft. Morgan	66	20	117° (13.2)	230° (18.0)	1964	Concrete culverts or pipes
Lipscomb	65	20	114° (13.9)	229° (16.5)	1972	Steel tugboat
Sparkman	93	28	120° (20.3)	206° (17.7)	1974	Liberty ship
Wallace	90	27	101° (25.3)	182° (10.5)	1974	Liberty ship
Kelly	60	18	100° (25.5)	181° (9.7)	1970	Concrete culverts or pipes
Allen	88	27	94° (26.3)	172° (8.0)	1974	Liberty Ship
Radmoor	72	22			1977	Concrete Ship
Orange Beach Lifeboats	88	27			1973	Cluster of 15-30 ft lifeboats
Dauphin Is. Bridge	80	24	190° (11.0)	240° (30.0)	1973	Concrete bridge
Trysler Grounds	102	31	119° (31.0)	174° (22.0)		
Mobil Oil Platform	96	29	113° (29.0)	184° (17.0)		Platform
Lillian Bridge #2	92	28	92° (27.5)	177° (9.0)		Concrete bridge
Southeast Banks	75	23	160° (11.6)	233° (27.8)		
Southwest Banks	66	20	269° (11.0)	239° (37.0)		

[a] Sponsored by Alabama Department of Conservation and Natural Resources.

provide access to Mobile Bay. Bottom fishing from shore and piers produces kingfish (ground mullet), saltwater catfish, croakers and red drum (Friend et al. 1981).

Fishing and recreational shrimping from private boats is also popular in Mobile and Baldwin Counties. Public boat launching and access areas sponsored by the Alabama Department of Conservation and Natural Resources (ADCNR) along with numerous private boat ramps provide nearby access to most areas of the gulf and bays. The ADCNR sites are free while the private boat launch ramps charge a small fee. The ADCNR access areas and private launch sites are indicated on the atlas sheets.

In addition to access areas and launch ramps, there are many marinas operated by private enterprises in the two counties which provide boating facilities and services. These marinas are located on the atlas sheets.

BARRIER ISLANDS AND SPITS

The following discussion of barrier formation is taken primarily from May (1976) and O'Neil and Mettee (1982). The existence of Dauphin Island (Biloxi quadrangle) and the Fort Morgan Peninsula (Pensacola quadrangle) across the

mouth of Mobile Bay has tremendous effects upon the salinity, sedimentation, erosion, and water currents within the bay. The exact processes by which these barrier islands and spits are formed are poorly known.

Whereas some Texas barrier islands rest on Pleistocene deposits, the sand bases of Dauphin Island and the Fort Morgan Peninsula are separated from the Pleistocene sediments by several feet of Holocene mud. Just to the west, in Mississippi Sound, the base of the sand between Cat, Ship, and Horn Islands (Biloxi quadrangle) was found by acoustic reflection to be 9 to 12 m (30 to 39 ft) below sea level (Curray and Moore 1963). May and McLain (1970) found barrier sand overlying mud at 9 to 11 m (30 to 36 ft) below sea level in the Bon Secour-Fort Morgan Peninsula area, using both physical probes and acoustic reflection. Kwon (1969) and Otvos (1973) have shown that part of Mobile Point (Biloxi quadrangle) is a relict Pleistocene ridge, and recent work by Otvos has shown that the same is true for at least the eastern end of Dauphin Island (May 1976).

Curray and Moore (1963) indicated that the barriers started forming near their present position when the postglacial rise of sea levels slowed and was outpaced by the upbuilding of sediments. Most gulf coast barrier islands probably formed about 5,000 to 3,500 years ago when the rise in sea levels slowed or stopped (Otvos 1970a, 1970b). Otvos also discussed the development and migration of barriers formed by aggradation of submerged shoals.

Although eroding to some extent, the eastern end of Dauphin Island has not migrated westward as has the western end, possibly due to its Pleistocene ridge base. The island is currently 24.35 km (15.13 mi) long, but sediment is accreting along the western end of the island, increasing its length about 6.4 km (4 mi) in the last 100 years (May 1971). Dauphin Island has a dune system averaging 3 to 6 m (10 to 20 ft) in altitude, reaching a maximum of 12.2 m (40 ft) at the eastern end of the island (Boone 1973). The dunes are fronted on the gulf side by broad well-developed beaches and on the bay side by beach interspersed with marsh.

The Fort Morgan Peninsula forms the southern boundary of Mobile Bay and, like Dauphin Island, has broad, well-developed beaches and a dune system reaching a height of 6 m (20 ft) along the western end. The eastern end, connected to the mainland, contains several large lagoons and marshes. O'Neil and Mettee (1982) state: "Several sets of intersecting dune ridges indicate a complex depositional history for this spit."

The only other component of the barrier island-spit system in Mobile and Baldwin Counties is Perdido Key (Pensacola quadrangle), only a small portion of which is located in Alabama. The central body of the key contains 6-m (20-ft) high dunes which decrease in frequency and height toward the ends of the key (U.S. Army Corps of Engineers 1971).

Ono Island (Pensacola quadrangle) north of Perdido Key can not be considered a true barrier island since it does not receive the direct wave action of the Gulf of Mexico. The island exhibits a series of parallel stable dune ridges with wet swales in the topographic depression between each pair of

ridges. The amount of vegetation on the dune ridges has tended to stabilize them.

POINT SOURCE DISCHARGES

The South Alabama Regional Planning Commission has made an assessment of both point and nonpoint sources of pollution in Mobile and Baldwin Counties and the controls needed to meet the goals of Section 208 of the 1972 amendment to the Federal Water Pollution Control Act. The South Alabama Regional Planning Commission (1979), Friend et al. (1981), and D. W. Brady (1979) are the primary sources of the following material, and should be consulted for more detailed information.

For purposes of this mapping study, point-source discharges have been divided into two categories: industrial sources that discharge effluent that may need chemical treatment; and municipal, semipublic and public sources that discharge domestic effluent that can generally be treated biologically.

In Mobile and Baldwin Counties there were 19 municipal waste-water point sources with an aggregate discharge of 208 million liters per day (mld) (55 million gallons per day (mgd)) in 1977. There were 38 industrial process waste-water sources with National Pollution Discharge Elimination System (NPDES) permits, with an aggregate discharge of about 507 mld (134 mgd). Also in the study area were 49 semipublic and private point sources of non-permit effluents such as sanitary waste, cooling water, boiler blowdown, and rain water runoff. Most of the industrial dischargers empty into Chickasaw Creek and the Mobile River (Mobile quadrangle). The greatest volume of discharge is from the two electrical generating plants, which discharge cooling water and steam condensate, and paper mills. In contrast, most of the pollution load comes from the paper mills and chemical plants.

The majority of point dischargers in Baldwin County are municipal wastewater treatment plants, of which there are seven, and municipal lagoons, of which there are three. The industrial discharges in Baldwin County are from several industries in the vicinity of Bay Minette (Bay Minette quadrangle), and about five seafood distributors in Bon Secour (Pensacola quadrangle).

Mobile County is more heavily populated and industrialized than Baldwin County, with nearly three times as many point source dischargers. There are 12 municipal wastewater treatment plants and several municipal lagoons in the county. Industrial dischargers include about a dozen chemical and mineral plants, most of which are located either in the Mobile area, the area around Bucks, or Theodore (Mobile quadrangle). Two large power plants are located on the Mobile River north of Mobile. Four paper/lumber plants, two railroad yards, and the State docks are also located in the Mobile area. A number of seafood distributors are located in Bayou La Batre (Biloxi quadrangle). Other information on water quality is included in the climatology and hydrology narrative.

SOLID WASTE LANDFILLS AND ONSHORE DISPOSAL SITES

There are approximately 148 ha (365 acres) of solid waste disposal sites in Mobile County, of these, 127 ha (315 acres) are sanitary landfills. All of the 32 ha (80 acres) of solid waste disposal sites in Baldwin County are sanitary landfills (South Alabama Regional Planning Commission 1979).

The following summary of approved solid waste disposal sites is taken from the Water Quality Management Plan, Mobile and Baldwin Counties, Alabama, developed by the South Alabama Regional Planning Commission (1979). These sites are the only approved sites for dumping in these counties, although there are approximately 70 unapproved sites which are used. Many of these unauthorized dumps are within the 3-m (10-ft) contour (NGVD) and are on private, industrial, and commercial properties. Often these unauthorized, unsupervised dumps result in groundwater contamination, runoff and floodwater pollution, air pollution from open burning and malodors, and pest problems (Alabama Coastal Area Board 1977).

Mobile County Citronelle Landfill (Citronelle quadrangle). This site as of May 1984 is not yet open, (D. Pruitt, South Alabama Regional Planning Commission, Mobile, 21 May 1984; pers. comm.). It was originally scheduled to open in 1978. A 12-ha (30-acre) site, it is in the drainage basin of Barrow Creek, which flows into David Lake and the Mobile River.

City of Citronelle Dump (Citronelle quadrangle). This location is to be closed upon the opening of the Mobile County Citronelle Landfill. It is an open burning dump, receiving household garbage and rubbish. An area of less than 4 ha (10 acres), it is in the drainage basin of Cedar Creek and the Mobile River.

City of Mobile Landfill (Citronelle quadrangle). This sanitary landfill opened in 1976 with 16 ha (40 acres) approved for use, with further expansion expected. This site receives waste only from the City of Mobile's municipal pickup service. It drains into Conrad Creek and the Mobile River.

City of Saraland Landfill (Citronelle quadrangle). Although not originally operated as a sanitary landfill, the site was upgraded to receive household garbage and rubbish. Runoff from this site of about 8 ha (20 acres) flows to Bayou Sara and the Mobile River.

Mobile County Kushla Landfill (Citronelle quadrangle). A sanitary landfill approved for 16 ha (40 acres), this site receives household wastes and rubbish. This site was opened in 1976 and drains into Seabury Creek, then Chickasaw Creek, and finally the Mobile River.

City of Chickasaw Dump (Mobile quadrangle). This 4-ha (10-acre) open burning site recently closed, the garbage brought here was transferred to the Mobile County Kushla Landfill. This site is drained by Chickasaw Creek which flows into the Mobile River.

Mobile County Dawes Landfill (Biloxi quadrangle). Opened in 1977, this site is approved for household garbage on 42 ha (105 acres). The area is

drained by Baker Creek, which flows into Miller Creek, then Big Creek, and the Escatawpa River.

Mobile County Irvington Landfill (Biloxi quadrangle). This 12-ha (30-acre) sanitary landfill was opened in about 1977 and was originally expected to provide service until 1982, but may close by March 1983 (D. Pruitt, South Alabama Regional Planning Commission, Mobile, 6 December 1982; pers. comm.). This site receives both solid waste and household garbage. Runoff from this site drains into the Fowl River.

Baldwin County Bay Minette Landfill (Bay Minette quadrangle). Twelve hectacres (30 acres) have been approved for this sanitary landfill, although only 2 ha (5 acres) were being used as of 1979. This site receives household garbage and other solid wastes. It is drained by Red Creek, a tributary of the Tensaw River.

Fairhope Landfill (Bay Minette quadrangle). This 4-ha (10-acre) landfill has been closed to all disposal except household rubbish due to various problems. Runoff flows into Tatumville Gully, which drains into Mobile Bay.

Baldwin County Magnolia Springs Landfill (Pensacola quadrangle). This 16-ha (40-acre) site serves as the sanitary landfill for southern Baldwin County. Although this site once accepted a small quantity of industrial sludges and liquid wastes, this is no longer the case. This area is drained by Barner Branch, a tributary of Fish River.

MAN-MADE LAND

Man-made land in coastal Alabama (Table 15) is essentially found in only three areas: a narrow strip of land along the Battleship Parkway (Mobile quadrangle) on the north shore of Mobile Bay, a narrow strip of land along the Dauphin Island Parkway (Biloxi quadrangle), and the Theodore Disposal Island (Mobile quadrangle). The Theodore Disposal Island is roughly triangular, its shape determined by water current movement studies in Mobile Bay by the U.S. Army Corps of Engineers. The island is basically a triangular levee, about 2.6 km (1.6 mi) to a side, into which spoil will continue to be dumped from the Theodore Ship Channel project. The island is expected to provide disposal space for about 50 years, at which time the island will consist of about 6.5 square km^2 (2.5 mi^2) of land about 4.6 to 6.1 m (15 to 20 ft) above sea level (J. Baxter, U.S. Army Corps of Engineers, Mobile, 15 December 1982; pers. comm.).

Although not man-made land in the strictest sense, many acres of marshy, estuarine wetland have been filled to provide stable, dry land for commercial purposes. As shown in Table 15, most of these are in the vicinity of Mobile, particularly where industrialized areas meet the Mobile Delta estuaries.

NATIONAL REGISTER OF HISTORIC PLACES

The following is a list of historic and prehistoric sites presently on the National Register of Historic Places in Baldwin and Mobile Counties. The majority of these sites are churches, residences, and business establishments

Table 15. Areas of Alabama estuaries filled between 1953 and 1968 (Alabama Coastal Area Board 1979 Chapman 1968).

Area	Emergent spoil banks (MLW) (acres)	(ha)	Causeways (acres)	(ha)	Housing or industry other uses (acres)	(ha)	Total (acres)	(ha)
Mississippi Sound							85	34.4
Graveline, Aloe and Dauphin Island bays (1)[a]	2	0.8	2	0.8	40	16.2		
Dauphin Island Airport (1)					35	14.2		
Miscellaneous	1	0.4			5	2.0		
Mobile Bay							858	347.2
Brookley Field Extension (2)							206	83.4
McDuffie Island Area (2)	14	5.7	3	1.2	230	93.1		
Battleship Park (2)					181	73.3		
Meaher Park (3)					88	35.6		
Pinto Island (2)					30	12.1		
Little Sand Island Area (2)							36	14.6
Miscellaneous			35	14.2	35	14.2		
Mobile Delta							1,196	484.0
Polecat Bay (2)					1,002	405.5		
Sardine Pass (2)					124	50.2		
Miscellaneous			35	14.2	35	14.2		
Perdido Bay (4)			1	0.4	10	4.0	11	4.4
Little Lagoon (4)					2	0.8	2	0.8
Total	17	6.9	76	30.8	2,059	833.4	2,152	871

[a] Quad sheets: (1) Biloxi, (2) Mobile, (3) Bay Minette, (4) Pensacola.

built in the nineteenth century. Of the two counties, Mobile contains more National Register sites, most of which are located in the City of Mobile's historic districts.

The listing is a synthesis of information from The National Register in Alabama (Alabama Historical Commission 1978a), Alabama's Tapestry of Historic Places (Alabama Historical Commission 1978b), and the most recent addendums to the National Register properties in Baldwin and Mobile Counties (M. Brooms, Historical Commission of Alabama, Montgomery, and Mobile Historic Development Commission, Mobile, 21 May 1984; pers. comm.). The National Register properties outside the City of Mobile are plotted individually. Most of the sites in the city are within the historic districts noted on the maps and not designated individually.

Mobile County

Name and Description	Location
Barton Academy (1)[a] 1837; Greek Revival; State's oldest public school; designed by James Gallier; now school system administrative office.	504 Government Street, Mobile
Battle House Royale (1) 1906-1908; Georgian Revival; seven-story hotel, the fourth at this site; among the first steel and concrete structures in the nation; became the city's social landmark; now closed.	26 North Royal Street, Mobile
Bellingrath Gardens (1) 1927; opened to the public in 1932; approximately 65 acres of the 800-acre estate are landscaped; includes an early 20th century home, two-story gumbo brick with wrought iron railing.	Theodore, near Mobile
Bishop Portier House (1) 1833; Creole cottage; home of the first bishop of the Catholic Diocese of Mobile and three later bishops; now a private residence.	307 Conti Street, Mobile
Bragg-Mitchell House (1) 1847; Greek Revival; home of John Bragg, judge and congressman; later owned by his brother, Confederate General Braxton Bragg; designed by Thomas James.	1906 Springhill Avenue, Mobile
Brisk and Jacobson Store (1) 1866; Classical Revival; large and ornate commercial building with excellent cast iron facade; now vacant.	51 Dauphin Street, Mobile
Carlen House (1) c. 1842; Greek Revival; formerly a farmhouse; renovated for used as a museum and meeting hall.	54 South Carlen Street on Murphy High School Campus, Mobile
Carolina Hall (Yester House) (1) 1832-1840; late Georgian; two-story residence with a two-story portico.	70 South McGregor Avenue, Spring Hill, Mobile

Cavellero House (1) c. 1835; Federal Style; two-and-a-half story masonry with one-story wing and dormers on steeply gabled roof.	7 North Jackson Street, Mobile
Church Street East Historic District (1) 19th century; Gulf Coast architecture; features 70 structures, several with wrought iron balconies.	Mobile's downtown area
City Hall-City Market (1) 1858; Italianate; ground floor of Mobile's municipal complex; once contained the Southern Market.	111 North Royal Street, Mobile
City Hospital (1) 1833; Greek Revival; one of the oldest hospitals in the Lower South; in operation for 125 years; now being restored for Pensions and Security offices.	850 St. Anthony Street, Mobile
Coley Building (1) 1836; two-story masonry building with cast iron Corinthian columns.	56 St. Francis Street, Mobile
Common Street Historic District (1)	Mobile's downtown area
Dahm Home (1) two-story brick structure has late Greek Revival influences.	7 North Claiborne Street, Mobile
Davis Avenue Branch Library (1)	564 Davis Avenue, Mobile
De Tonti Square Historic District 19th century; Gulf Coast influences; features 53 structures in nine-block area.	Mobile's western downtown area
Denby House (1)	558 Conti Street, Mobile
Ellicott Stone (2) 1799; marks 31st parallel, early boundary between Spain and the United States.	Approximately 1 mi north (1.6 km) of Bucks off U.S. route 43
Emanuel-Staples-Parke Building (1) 1850s; Italian Renaissance Revival; built as offices by a Mobile cotton broker; remodeled in 1903 by prominent Mobile architect Georgia B. Rodgers for Bank of Mobile.	100 Royal Street, Mobile

Fire Department Headquarters (station #5) (1) — 7 North Lawrence Street, Mobile
1859; two-story masonry structure first housed Mobile's volunteer fire companies.

First Baptist Church (1) — 806 Government Street, Mobile

First National Bank of Mobile (1) — 68 Saint Francis Street, Mobile

Fort Conde-Charlotte (1) — 104 Theatre Street, Mobile
1711; French fort was reconstructed by the City of Mobile.

Fort Conde-Charlotte House (Kirkbride House) (1) — 104 Theatre Street, Mobile
1822; Federal-Greek Revival; residence built on site of French fort; now a house museum, headquarters of the National Society of Colonial Dames of Alabama.

Fort Gaines (3) — East end of Dauphin Island
1818; five-sided brick fort was one of two forts guarding the entrance of Mobile Bay; not completed until the Civil War; open to the public.

Fort Louis de la Louisiane (4) — Near Twenty-Seven Mile Bluff on the Mobile River
1702; location of the capitol of French Louisiana, 1702-1711.

Gates-Davis House (1) — 1570 Dauphin Street, Mobile
1842; Creole plantation cottage; best example of this uncommon style in Mobile.

Georgia Cottage (1) — 2564 Spring Hill Avenue, Mobile
1845; Greek Revival with Creole influences; was the home of Augusta Evans Wilson, Southern novelist popular during the last half of the 19th century.

Greene-Marston House (1) — 2000 Dauphin Street, Mobile
1851; Eclectic; stagecoach stop; complexity of frame structure unequaled in Mobile.

Gulf, Mobile and Ohio Passenger Terminal (1) — Beauregard and Saint Joseph Street, Mobile
1907; Spanish Colonial Revival; massive and ornate structure; one of two remaining large-scale railroad stations in the state; now used for offices and storage.

Horst House ("Moongate") (1) 1868; Italianate with Greek Revival details; two-story brick structure built by a German immigrant who became Mayor of Mobile; now a restaurant.	407 Conti Street, Mobile
Indian Mound Park (3) 7.28 ha (18 acre) site of six prehistoric Indian shell mounds.	Iberville Drive, Dauphin Island
Lower Dauphin Street (Historic) Commercial District (1)	Mobile
Marine Hospital (Sixth District Tuberculosis Hospital) (1) 1843; Greek Revival; massive H-shaped structure was a hospital for seamen for more than a century.	800 Saint Anthony Street, Mobile
Meaher House (1)	5 North Claiborne Street, Mobile
Metzger House (1)	7 North Claiborne Street, Mobile
Middle Bay Light (Blue Ford Landing) (3) 1905; one and a half-story wooden hexagonal structure on metal pilings; unusual combination of lighthouse and lightkeeper's residence; no longer used, but has been restored.	Mobile Bay
Miller-O'Donnell House (1) 1837; Raised cottage style; two-story structure with first floor masonry, second floor frame.	1102 South Broad Avenue, Mobile
Monterey Place House (1)	1552 Monterey Place, Mobile
Murphy High School (1)	100 South Carlen Street, Mobile
Nanna Hubba Bluff (Blue Ford Landing) (4) Several sites indicate habitation by prehistoric and historic Indians.	On the west bank of the Tombigbee River near the Washington County line
Neville House (1) 1896; two-story brick building contains a rare example of terra cotta ornament.	255 St. Francis Street, Mobile

Oakleigh (1) — 350 Oakleigh Place, Mobile
1833; Greek Revival; T-shaped raised cottage; now a house museum and headquarters of the Historic Mobile Preservation Society.

Oakleigh Garden Historic District (Washington Square) (1) — Mobile
1833-1898; 19th century styles; 125 structures in this residential district.

Phillippe House (1) — 53 North Jackson Street, Mobile

Pincus Building (1) — One South Royal Street, Mobile
1891; late Victorian Eclecticism; originally housed a jewelry store; designed by Rudolf Benz.

Protestant Children's Home (1) — 911 Dauphin Street, Mobile
1845; Greek Revival detailing; one of the first buildings in Alabama constructed for philanthropic purposes; it was an orphanage until 1950; now vacant.

Saint Francis Street United Methodist Church (1) — 251 St. Francis Street, Mobile

St. Louis Street Missionary Baptist Church (1) — 114 North Dearborn Street, Mobile
c. 1872; Eclectic style; two-story church; one of four black churches organized in Mobile before the Civil War.

Scottish Rite Temple (1) — Claiborne and St. Francis Streets, Mobile
1922; Egyptian design

Semmes House (1) — 804 Government Street, Mobile
1858; Federal and Greek Revival; home of Admiral Raphael Semmes, commander of the Confederate States Ship CSS Alabama; now a First Baptist Church building.

South Lafayette Street Creole Cottages (1) — 20, 22, and 23 Lafayette Street, Mobile
c. 1850; Creole cottages; residences are fine examples of Creole cottages, with Greek Revival influence.

Spring Hill College Quadrangle (1) 1866-1909; Gothic Revival, Italianate and French Renaissance; Spring Hill College is the oldest institution of higher learning in Alabama; quadrangle consists of six structures.	4307 Old Shell Road, Mobile
Staples-Pake Building (1) late 1800s; formerly Bank of Mobile; spiral stairway with fine architectural features and bronze hardware.	100 South Royal Street, Mobile
State Street AME Church (1)	502 State Street, Mobile
Tschiener House (Damus School) (1)	1120 Old Shell Road, Mobile
Vickens-Schumacker Building (1)	707-11 Dauphin Street, Mobile
Weems House (1)	1155 Springhill Avenue, Mobile

[a]Quad sheets: (1) Mobile
(2) Citronelle
(3) Biloxi
(4) Atmore.

Baldwin County

Name and Description	
Blakeley Site (1)[a] Early 1800s; foundations; site of a once major town which contains breastworks of an 1865 Civil War battle; is proposed for development by Historic Blakeley Foundation.	Off Alabama route 225, 5 mi (8 km) north of Spanish Fort
Bottle Creek Indian Mounds (2) Approximately 1400 A.D. to 1600 A.D.; largest temple mound complex in South Alabama, contains six mounds; closed to the public.	Stockton
Daphne Methodist Church (1) 1858; constructed of heart pine and pegs with slave gallery; church bell is lined with silver dollars.	Daphne
Fort Mims Site (2) 1813; excavations; site of one of the biggest massacres of colonists by Indians in the history of the nation; being excavated by archaeologists.	Between the Tensaw and the Alabama Rivers

Fort Morgan (3) 1833; partially restored; major military installation prominent in Battle of Mobile Bay in 1864; owned by the State of Alabama and open to the public.	At entrance to Mobile Bay at Mobile Point
Montrose Historic District (1) Mid-19th century; Greek Revival influences; this collection of 27 Creole cottages shows the Greek Revival influence.	Main and Second Streets, Montrose
Sand Island Light (3) 1873; influenced by Italianate style; the 132 ft (40 m) tall conical masonry tower is the older of two remaining lighthouses in the state.	Mouth of Mobile Bay, 3 mi (5 km) south of Mobile Point
U.S.S. Tecumseh (3) Aug. 5, 1864; 225 ft (69 m) long ironclad; one of four Union ironclad monitors, the Tecumseh struck a marine mine and sank during the Battle of Mobile Bay and is in an excellent state of preservation underwater.	Under 30 ft (9 m) of water in Mobile Bay north of Fort Morgan

[a]Quad sheets: (1) Bay Minette
(2) Atmore
(3) Biloxi.

ARCHAEOLOGICAL SITES

The Alabama coast is believed to have been inhabited as early as 10,000 B.C., although no sites dating to this period, the Paleo-Indian stage, have been discovered as yet in this region. The earliest datable artifacts in Alabama's coastal plain can be assigned to the Early Archaic Period, ranging from 8000 to 6000 B.C. (Walthall 1980). Sites known in Baldwin and Mobile Counties date from the Late Archaic period, (1000 B.C.) through the Historic Period (post 1500). By 1979, 196 archaeological sites had been located in Baldwin County, while 36 sites had been recorded in Mobile County (U.S. Army Corps of Engineers 1981). It is estimated that there may be as many as 2,000 significant archaeological sites in Mobile and Baldwin Counties (Alabama Coastal Area Board 1978).

Most of the prehistoric sites in Mobile and Baldwin Counties are shell mounds and middens, ceremonial and burial mounds, and villages representing Late Archaic, Woodland, and Mississippian Periods of cultural development (1000 B.C.-A.D. 1500). The Late Archaic Period is characterized by the appearance of shell mounds and rings and the introduction of ceramics. The shell mounds indicate seasonal habitation of base camps, the population of which relied on the availability of shellfish. This pattern of subsistence was more sedentary than that suggested by the material culture of previous

periods. Hallmarks of the Woodland Period (1000 B.C.-A.D. 1000) include the persistence of seasonal hunting and gathering, indicated by the build-up of shell refuse mounds; widespread manufacture of plain and decorated ceramics (fiber-tempered pottery early in the period and later, sand-tempered); and evidence of systematic horticulture and burial-mound construction.

The Mississippian Period (A.D. 900-1500) continued and further developed the construction of burial mounds. Other features of this period include village sites, the construction of elaborate ceremonial mounds, and the practice of intensive agriculture. These traits indicate that the Mississippian people had a fairly organized and sedentary society and no longer based their subsistence on the seasonal availability of food resources. Diagnostic artifacts of this period are shell-tempered ceramics; small triangular stone points, suggesting the use of the bow and arrow; and elaborate grave goods, which in conjunction with the mounds, indicate an advanced degree of religious ceremonialism (Walthall 1980).

Sites along the coast include the shell mounds and burial sites at Bayou La Batre, Bayou Coden, Shell Bank Bayou, Dauphin Island, and the Fort Morgan Peninsula (Biloxi quadrangle). Other sites, many of which are located in the Mobile-Tensaw River Delta (Atmore quadrangle), include the Bottle Creek Indian Mounds (Atmore quadrangle), D'Olive Creek Shell Middens (Bay Minette quadrangle), Grand Bay village sites (Bay Minette quadrangle), and Dead Lake shell mounds and middens (Mobile quadrangle) (Alabama Coastal Area Board 1978, U.S. Fish and Wildlife Service 1981). Exact locations and descriptions of the Baldwin and Mobile County sites have been omitted to avoid the possibility of damage that might result from public knowledge of the data.

Only a few areas of the coast have been adequately surveyed for the presence of archaeological sites. In general, however, the margins of Mobile Bay and Mississippi Sound, the distributary margins of the Mobile-Tensaw River delta, and margins of most permanent streams are considered among the most archaeologically sensitive areas in the Alabama coastal region (V. J. Knight, Jr., the University of Alabama, Moundville, 15 March 1983; pers. comm.).

Potential developers are urged to contact the following agencies for further information concerning archaeological sites and relevant protective legislation concerning them. The State Archaeological Site Files are on deposit at

The Office of Archaeological Research
The University of Alabama
1 Mound State Monument
Moundville, Alabama 35474
(205) 348-7774.

The State Historic Preservation Officer is

Mr. F. Lawrence Oaks
State Historic Preservation Officer
Alabama Historical Commission
725 Monroe Street
Montgomery, Alabama 36104
(205) 832-6622.

NAVIGATION CHANNELS

The navigation channels in Mobile and Baldwin Counties (Table 16) include channels providing access to the Port of Mobile, to smaller ports, such as Bayou La Batre, Bon Secour, and Theodore, and the Intracoastal Waterway, which provides for lateral vessel movement along the coast. The following information was supplied by the U.S. Army Corps of Engineers, Mobile District office (J. Baxter, U.S. Army Corps of Engineers, Mobile, 7 December 1982; pers. comm.; U.S. Army Corps of Engineers 1980a).

The Mobile Ship Channel requires maintenance dredging on the average every 1.5 years, at which time a total of about 3 million m^3 (4 million yd^3) of deposits are removed from the bay channel. In addition, 841 thousand m^3 (1.1 million yd^3) of this comes from the river portion of the channel. Siltation in the 10 to 12 m (32 to 40 ft) deep river and 12 m (40 ft) deep bay portion of the channel is about 0.3 m (1 ft) per year, whereas the 13 m (42 ft) deep bar channel outside of Mobile Bay accumulates 0.6 m (2 ft) per year. Shipping tonnage by deep-draft vessels into the Port of Mobile increased from 13.1 million metric tons (14.4 million short tons) in 1966 to 15.1 million metric tons (16.7 million short tons) in 1975. Barge traffic increased from 7.2 to 14.3 million metric tons (7.9 to 15.8 million short tons) over the same period.

In Chickasaw Creek, upstream of the Mobile Ship Channel, the 8 m (25 ft) deep Chickasaw channel accumulates silt at at the rate of 0.3 m (1 ft) per year. Just south of McDuffie Island, the Arlington Channel is 8 m (27 ft) deep and fills at the rate of 0.5 m (1.5 ft) per year.

The 2.4 m (8 ft) deep Fowl River channel accumulates silt at the rate of 0.6 m (2 ft) per year and was last dredged in 1980. The Bayou La Batre channel, 4 m (12 ft) deep, fills in at 0.5 m (1.5 ft) per year and was dredged in 1978 and 1982.

DREDGE SPOIL DISPOSAL AREAS

The dredging of new navigational channels in coastal Alabama, as well as the maintenance dredging of the numerous existing channels, generates tremendous volumes of spoil that must be disposed of in an environmentally acceptable manner. There were 206.6 km (128.4 mi) of navigational channels in the area, with a surface area of 1384 ha (3420 acres) in 1974 (Alabama Coastal Area Board 1979). The completion of the Theodore Ship Channel (Mobile quadrangle) has increased this amount by 28.3 km (17.6 mi) and 184 ha (456 acres).

Table 16. Maintained navigable channels in coastal Alabama (U.S. Army Corps of Engineers 1980, 1983).

Atlas quad sheet	Channel name	Depth x width (ft)
Mobile	Theodore Ship Channel (Mobile Bay portion)	40 x 400
Mobile	Arlington Channel	27 x 150
Mobile	Garrows Bend Channel	27 x 150
Mobile	Mobile River Channel	40 x 500-700
Mobile	Hollingers Island Channel	([a])
Mobile	Dog River Channel	
	Mobile Bay portion	8 x 150
	inland portion	6 x 60-100
Mobile/Biloxi	Mobile Bay Channel	40 x 400
Biloxi	Aloe Bay Channel	7 x 100
Biloxi	Drury Pass Channel	4 x 40
Biloxi	Fort Gaines Jetty Channel	7 x 150
Biloxi	Bayou La Batre Channel	12 x 100
Biloxi	Bayou Coden Channel	
	Mississippi Sound portion	8 x 100
	Bayou Coden portion	8 x 60
Biloxi	Bar Channel	42 x 600
Biloxi	Fowl River Channel	8 x 100
Bay Minette	Fly Creek Channel	
	Mobile Bay portion	6 x 80
	inland portion	6 x 60-100
Pensacola	Perdido Pass Channel	
	Gulf of Mexico portion	12 x 150
	Perdido Pass/Bay portion	9 x 100
Pensacola	Bon Secour Channel	6-10 x 80
	Gulf Intracoastal Waterway	
Biloxi	Mississippi state line to Mobile Bay	12 x 150
Pensacola	Mobile Bay to Florida state line	12 x 125

([a]) No data available; non-Federally maintained.

Maintenance dredging of the Mobile Ship Channel (Mobile and Biloxi quadrangles) between 1968 and 1973 produced 11,469,000 m^3 net (15,000,000 yds^3 net) of spoil (Alabama Coastal Area Board 1979). The average annual net volumes of dredged maintenance material produced from the Mobile Harbor system between 1967 and 1975 are shown in Table 17.

Almost all of this dredged material is dumped in disposal areas designated by the U.S. Army Corps of Engineers approximately 548 m (600 yd) on either side of most of the channels in the area. Onshore dredge spoil disposal areas include sites at Theodore (Mobile quadrangle), Bayou La Batre (Biloxi quadrangle), and Blakely Island (Mobile quadrangle). On Blakely Island, the U.S. Army Corps of Engineers covers mineral residue ponds with dredge spoil, which provides both needed area for spoil disposal and covering for potentially harmful chemical waste (J. Baxter, U.S. Army Corps of Engineers, Mobile, 15 December 1982; pers. comm.).

OFFSHORE OBSTRUCTIONS AND STRUCTURES

The only major offshore structures in Mobile and Baldwin Counties are the Mobile Bay Light, the Sand Island Light and three petroleum platforms associated with the Lower Mobile Bay Field (Biloxi quadrangle). The Middle Bay Light was constructed in 1884 and is located, as the name implies, in the middle of Mobile Bay on the navigation channel. This structure is discussed further in the atlas section dealing with the National Register of Historic Places.

The Sand Island Lighthouse is located near Sand Island about 5 km (3 mi) south of the mouth of Mobile Bay. It dates to 1873 and was abandoned in 1971. Like the Middle Bay Light, it is on the National Register of Historic Places and is discussed further in that section.

Table 17. Average annual volume of maintenance bottom materials dredged from the Mobile Harbor system, 1967-75 (U.S. Army Corps of Engineers 1980).

Channel	Amount (yd^3/yr)
Mobile River (including Chickasaw Creek)	1,054,000
Mobile Bay	3,743,000
Mobile Bar Channel	264,000
Total	5,061,000

Mobil Oil discovered gas in a deep well at the mouth of Mobile Bay in late 1979. This well produced enough to encourage further drilling and, as a result, there are now three platforms near the mouth of Mobile Bay in what has been designated the Lower Mobile Bay Field (R. G. Hellmich, Alabama State Oil and Gas Board, University, September 1982; pers. comm.). The number of offshore petroleum platforms will soon increase as an additional 13 tracts have been leased by the State for petroleum exploration (Hagopian 1981).

Underwater obstructions and shipwrecks are plotted on both the U.S. Geological Survey 7.5 min quadrangle maps and the National Oceanic and Atmospheric Administration (NOAA) navigational charts of the area. Although the composition of obstructions are usually not identified on NOAA charts, some are submerged snags, pilings, or privately established fish havens.

Shrimpers who regularly work in an area generally maintain an exhaustive list of snag locations. A single shrimpboat may net a 61 m (200 ft) wide swath of bottom at one time, and the chance of a snag fouling a shrimper's net is quite high. Because a single snag may result in the loss of thousands of dollars worth of fishing gear, shrimpers pay close attention to their location and exchange information on snag locations with other shrimpers. Although these snags are, in size and number, beyond the mapping scale of this study, the shrimping community is a valuable source for anyone seeking detailed information on the sea floor.

Many shipwreck locations are generally well known and new sites are reported to the U.S. Coast Guard by boaters. Excluding shipwrecks in rivers, there are approximately 25 known shipwrecks in the study area, of which about 5 are in shallow enough water to be partially exposed. The most famous shipwreck in Alabama waters is the Civil War ironclad vessel U.S.S. Tecumseh. The wreck is in fairly good condition under about 9 m (30 ft) of water just north of Fort Morgan. The U.S.S. Tecumseh is listed in the National Register of Historic Places and is discussed further in that section.

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This is a color brochure showing the geographic location of all Alabama State Parks and containing a matrix that cross-indexes individual parks with facilities and activities.

Alabama Department of Conservation and Natural Resources. 1981. Frank W. and Rob M. Boykin Wildlife Management Area. (Alabama Department of Conservation and Natural Resources, Game and Fish Division, Montgomery.)

A detailed map of the wildlife management area, with the hunting regulations printed on the reverse side.

U.S. Fish and Wildlife Service. 1980. Bon Secour National Wildlife Refuge: a proposal. U.S. Fish and Wildlife Service, Region 4, Atlanta, GA.

This consists of narrative text printed on the reverse side of a colored map folded as a brochure.

U.S. National Park Service, 1974 (Unpubl.) National landmark brief: Mobile-Tensaw River bottomlands. U.S. Nat. Park Serv., Washington, DC. 3 pp.

Two pages of text describing the Mobile Delta, its unique biological resources, and possible threats to its integrity. Contains a small-scale (1 inch = 4 mi) map with a rough outline of the landmark.

National Audubon Society Sanctuaries

Mobile Chamber of Commerce. 1963. Dauphin Island, Alabama (map). (Mobile Chamber of Commerce, Mobile, AL.)

A detailed, large-scale (1 inch = about 0.25 mi) map of the island.

Intensively Used Recreation Beaches

D. W. Brady, South Alabama Regional Planning Commission, Mobile, AL, January 1982, pers. comm.

Public Fishing Piers

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U.S. Geological Survey. 7.5-minute-quadrangle-maps. (U.S. Geol. Surv., Reston, VA.)

Detailed, colored 1:24,000 scale maps containing many man-made features (although many of the maps are out-of-date and do not show recent construction).

Charter Boat and Head Boat Service

L. Schmied, 3 June 1981 Letter, National Marine Fisheries Service, St. Petersburg, FL to Villere C. Reggio, Jr., Bur. Land Manage., New Orleans, LA.

Public Access Areas (boat ramps)

Alabama Department of Conservation and Natural Resources. 1981. Public access areas. Ala. Dept. Cons. Nat. Res., Game and Fish Div., Montgomery.

A small-scale (1 in = 8 mi) State map with the public access areas listed by name along with their location.

Marinas

Chermock, R. L. 1974. The environment of offshore and estuarine Alabama. Geol. Surv. Ala. Info. Ser. 51. 135 pp.

A general description of the geography, hydrology, climate, flora and fauna, recreation, and seafood industry of coastal Alabama. Numerous maps and illustrations, including information on navigation, sport fishing facilities, and water pollution.

Barrier Islands and Spits

O'Neil, P. E., and M. F. Mettee. 1982. Alabama coastal region ecological characterization. Vol. 2. A synthesis of environmental data. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-81/42. 346 pp.

Contains detailed analysis of the hydrology, geology, climate, flora and fauna of coastal Alabama. Also a detailed description of the area, with maps and conceptual models.

Point Source Discharges

Alabama Coastal Area Board. 1979. The Alabama coastal area management program (hearing draft). (Alabama Coastal Area Board, Daphne, AL.)

Contains broad information and description of the area, including archaeological sites, pollution sources, geology, water quality, recreation areas, etc. Numerous maps of commercial activities and natural resources.

South Alabama Regional Planning Commission. 1979. Water quality management plan, Mobile and Baldwin Counties, Alabama. South Alabama Regional Planning Commission, Mobile, AL.

Large document prepared as partial requirement of Public Law 92-500, the Federal Water Pollution Control Act Amendments of 1972, Section 208. Contains water quality assessments, standards, needs, and projections. Basic water planning document for coastal counties of Alabama.

Friend, J. H., M. Lyon, N. Garrett, J. L. Borom, J. Ferguson, and G. C. Lloyd, 1981. Alabama coastal region ecological characterization: Vol. 3: A socioeconomic study. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-81/41. 367 pp.

Contains socioeconomic analysis of coastal Alabama, with information on recreational and commercial fishing. Brief description of major biomes in area.

Solid Waste Landfills

Alabama Coastal Area Board. 1979. The Alabama coastal area management program (hearing draft). Alabama Coastal Area Board, Daphne, AL.

Contains broad information and description of the area, including archaeological sites, pollution sources, geology, water quality, recreation areas, etc. Numerous maps of commercial activities and natural resources.

South Alabama Regional Planning Commission. 1977. Environmental baseline study for Mobile 208 wastewater management plan. South Alabama Regional Planning Commission, Mobile, AL.

Onshore Disposal Sites

U.S. Geological Survey. 7.5-minute-quadrangle maps. (U.S. Geological Survey, Reston, VA.)

Detailed, colored 1:24,000 scale maps containing many man-made features (many of the maps are out-of-date and do not show recent construction).

National Aeronautics and Space Administration. 1 November 1979. False-color infrared aerial photography. Scale 1:62,500.

Man-Made Land

Baxter J., 15 December 1982, U.S. Army Corps of Engineers, Mobile, AL., pers. comm.

U.S. Army Corps of Engineers. 1980. Dauphin Island Bay, Dog and Fowl Rivers, and Mobile Harbor maps. U.S. Corps of Engineers, Mobile District, Mobile, AL.

A group of colored maps of varying scale, punched to fit in a looseleaf binder. Maps show location and dimension of channels and mileages, and location of Theodore Disposal Island. Accompanying pages give textual account of the condition, progress, and costs of each project.

National Register of Historic Places

Alabama Historical Commission. 1978b. The National Register in Alabama. Alabama Historical Commission, Montgomery, AL. 16 pp.

An illustrated listing by county of all the National Register sites in Alabama. Includes location and the significant features of each site, as well as the date the site was named to the register.

Alabama Historical Commission. 1978c. Alabama's tapestry of historic places. Alabama Historical Commission, Montgomery, AL. 201 pp.

A listing of all the historic sites in Alabama, including National Register sites, National Historic Landmarks, sites from the National Survey of Historic Sites and Buildings, and sites of local interest. Includes location and significant features of each site.

Archaeological Sites

Alabama Historical Commission. 1978a. (unpubl.) Site file. Alabama Historical Commission, Montgomery, AL.

An unpublished computer printout of all known archaeological sites in each county. Gives location of site to the nearest quarter of a quarter section, status, current land use, surface area of site, and culture represented by each site.

Navigation Channels, Dredge Disposal Areas, and Shipwrecks

National Oceanic and Atmospheric Administration. 1979. Navigational map 11376 (Mobile Bay). National Oceanic Atmospheric Administration, National Ocean Survey, Washington, DC.

Contains locations of shipwrecks, navigation channels, major offshore structures, etc.

National Oceanic and Atmospheric Administration. 1980. Navigational map 11373 (Mississippi Sound and approaches). (National Oceanic and Atmospheric Administration, National Ocean Survey, Washington, DC.)

Contains locations of shipwrecks, navigation channels, major offshore structures, etc.

U.S. Geological Survey. 7.5-minute-quadrangle maps. (U.S. Geological Survey, Reston, VA.)

Detailed, colored 1:24,000 scale maps containing many man-made features (many of the maps are out-of-date and do not show recent construction).

Offshore Obstructions and Structures

National Oceanic and Atmospheric Administration. 1979. Navigational map 11376 (Mobile Bay). (National Oceanic and Atmospheric Administration, National Ocean Survey, Washington, DC.)

Contains locations of shipwrecks, navigable channels, major offshore structures, etc.

National Oceanic and Atmospheric Administration. 1980. Navigational map 11373 (Mississippi Sound and approaches). (National Oceanic and Atmospheric Administration, National Ocean Survey, Washington, DC.)

Contains locations of shipwrecks, navigable channels, major offshore structures, etc.

Hellmich, R. G., Alabama State Oil and Gas Board, University, AL, September 1982; pers. comm.

SOILS AND LANDFORMS

INTRODUCTION

This atlas topic deals with the natural phenomena of soils, landforms, and related subjects, which includes regional surface landforms, soils, beach erosion and accretion areas, faults, high-energy beaches, and active dunes.

This narrative supplements the atlas maps by explaining not only how and where environmental conditions currently exist but also how they have appeared or evolved in the past. The information is relevant to decision-makers charged with duties ranging from preservation and conservation to responsible, economically feasible land and resource development.

REGIONAL SOILS AND LANDFORMS

The most detailed soil classification is the soil phase. A soil phase is a subdivision of a soil series based on differences that affect management of that subdivision. A soil series may be divided into phases on the basis of differences in slope, thickness (depth), stoniness, or any other characteristic that affects its usage. An example of a soil phase would be "Troup loamy sand, 5% to 8% slopes."

Groups of soils derived from similar parent material and similar in vertical profile characteristics and arrangement are called soil series. Soils within a series may have some variation in the texture of the surface horizon (layer), but are similar to one another in color, structure, reaction, chemical composition, and overall consistency.

A group of soil series that is found in the same geographical area and generally occurs in a characteristic pattern is called a soil association. For example, the Izagora-Bethera-Suffolk soil association (map unit 13) is where Izagora soils are found on higher, flatter areas; Bethera soils are found in the depressions and drainage ways, and Suffolk soils are found on the slopes connecting the two. These associations are usually defined and delineated as a single map unit, and are the basic units dealt with in this atlas. Although most of the areas in an association are composed of major soil series, there are a number of other soil series within the association which are less common; these are called minor soils.

The soil association maps available in the soil surveys of Mobile (Hickman and Owens 1980) and Baldwin (McBride and Burgess 1964) Counties are at 1:316,800 scale, (1 cm = 3.2 km, 1 inch = 5 mi). This information was transferred to the 1:100,000 (1 cm = 1 km, 1 inch = 1.6 mi) scale

atlas maps. Although the information appears to be fairly accurate and detailed at the 1:100,000 scale, it is still generalized, and the 1:20,000 scale maps within the soil survey should be consulted for detailed information.

The soil surveys of Mobile and Baldwin Counties were classified 18 years apart (field work done in 1978 and 1960, respectively) by different soil scientists using different classification schemes. While this is not an unusual situation, the result is that the soil association methodologies used in the two counties are almost mutually exclusive. The soil names used in the 1960 Baldwin County survey have been translated into more modern nomenclature for inclusion in this atlas (G. L. Hickman, Soil Conservation Service, Grove Hill, 10 May 1982; pers. comm.).

Baldwin is the largest county in Alabama, with a surface area of 4,178 km^2 (1,613 mi^2, 1,032,320 acres, 418,090 ha), while Mobile County covers 3,212 km^2 (1,240 mi^2, 793,472 acres, 321,356 ha). Elevations range from sea level to about 104 m (340 ft) in Mobile County and about 91 m (300 ft) in Baldwin County. Both counties lie within the Lower Coastal Plain of the Gulf Coastal Plain physiographic province. Offshore, the coastal waters belong to the Mississippi-Alabama Shelf Section of the Continental Shelf physiographic province.

The Lower Coastal Plain province is subdivided within the study area into the Southern Pine Hills and the Coastal Lowlands. The lowlands include both the alluvial and deltaic plains. The Coastal Lowland zone is a flat to gently undulating plain along the Alabama coast which is continuous with the alluvial and deltaic plains of the Mobile River delta. The lowlands range in width from 16 km (10 mi) in the Mobile Delta to only 60 m (200 ft) along the eastern edge of Mobile Bay, and are generally 3 to 8 km (2 to 5 mi) in width along the Gulf of Mexico. The transition from Coastal Lowlands to Southern Pine Hills may be quite gradual, or fairly abrupt, in the form of bluffs (Alabama Coastal Area Board 1978). Bordering the Mobile Delta, the alluvial and deltaic plains and adjacent terraces are mainly silt and clay sediments relocated from upstream in Recent or Pleistocene times. Elevation here ranges from nearly sea level to only about 7 m (20 ft), making the area vulnerable to frequent flooding and saltwater intrusion, particularly during extreme tides or storms. Predominant soil associations of the alluvial-deltaic plain include Axis-Lafitte (6), Dorovan-Levy-Iuka-Urbo (1), Dorovan-Johnston-Levy (12), Annemaine-Wahee-Leaf (2), and Izagora-Bethera-Suffolk (13).

The Axis-Lafitte association (6) is level, very poorly drained marshland. The Axis soils are loamy mineral soils of tidal flats. They are gray to brown mucky sandy clay loam overlying gray sandy loam with mottles or streaks of yellow or brown. The land is covered with dense stands of marsh cane, marsh grass, and rushes. Lafitte soils comprise mostly black to brown mucky organic material and are found at the mouths of streams and rivers. These areas are mostly wetland wildlife habitat and undeveloped.

The Dorovan-Levy-Iuka-Urbo association (1) of Baldwin County and the Dorovan-Johnston-Levy association (12) of Mobile County are the soils of the

broad flood plains of the Mobile/Alabama/Tensaw Rivers (Mobile quadrangle) and the Grand Bay Swamp (Biloxi quadrangle). The land here is level, frequently flooded, swampy bottomland with meandering streams and sloughs and a very high water table. These areas are mainly used as wetland wildlife habitat and woodlands. The organic Dorovan soils are found in the wetter, lower areas of the flood plain and comprise grayish-brown to black mucky peat overlying mottled dark grayish-brown to mottled gray subsoil. Levy soils are dark-gray silty loam overlying dark-gray silty clay subsoils on higher ground than Dorovan soils and are adjacent to natural levees along streams. The Iuka soils are dark-brown fine sandy loam overlying dark yellowish-brown fine sandy loam subsoils with mottles of grayish-brown and interpersed with loamy sand and loam. The Johnston soils are also found at higher elevations than the Dorovan soils, in flat areas adjacent to uplands. Their surface is thick black mucky loam overlying gray loamy fine sand and fine sandy loam layers. The Urbo soils have a dark grayish-brown silty clay loam topsoil underlain by grayish-brown silty clay subsoil. They are found in level to gently sloping flood plains draining coastal plains and prairie areas.

The Annemaine-Wahee-Leaf association (2) is found on the terraces bordering the Mobile/Alabama/Tensaw Delta in Baldwin County, whereas the terraces along the delta (and along the Escatawpa River) in Mobile County are of Izagora-Bethera-Suffolk association (13) soils. These areas are fairly wet woodlands, with little agriculture, and are sparsely populated. The lower lying areas of the Annemaine-Wahee-Leaf association are comprised of Leaf soils, which have dark grayish-brown silt loam over a subsoil of mottled gray silty clay. The Annemaine soils are moderately well-drained, deep soils with a brown fine sandy loam surface layer, a subsoil of yellowish-red clay, and a mottled loamy substratum. The Wahee soils are not as well drained as the Annemaine, and they differ in having a surface layer of dark grayish-brown sandy loam overlying a mottled yellowish-gray sandy clay or sandy clay loam subsoil.

The Izagora-Bethera-Suffolk association (13) soils were formed in loamy and clayey marine and alluvial sediments on terraces. Izagora and Suffolk soils have loamy subsoils, whereas Bethera soils overlie clayey subsoils. Izagora series soils have a dark brown fine sandy loam surface while Suffolk series soils have dark brown loamy sand surface. Bethera series soils have dark gray loam surface layers, and are located in depressions and drainage ways. The more sloping areas adjacent to natural drainage ways contain Suffolk soils, and above them are the Izagora soils on the gently sloping side slopes and broad flat areas. These areas are mostly woodland, although there is some agricultural potential. As this area is wet and flood prone, it is poor for urban uses.

The major component of the Coastal Lowlands, exclusive of the alluvial and deltaic plains, is the coastal beach area. This area is composed of white and yellow sand deposits of Recent age, with elevations ranging from sea level to around 7 m (20 ft). In Baldwin County, the coastal beach areas are usually associated with the Fripp-Leon soil association (9). The Coastal Lowlands in Mobile County include the Bayou-Escambia-Harleston association (15) along the coastal terraces in the southern portion of the county, and the Urban Land-Smithton-Bennedale association (16) in the city of Mobile.

The previously discussed Axis-Lafitte (6) and Dorovan-Johnston-Levy associations (12) are also found along the coast of southern Mobile County and just inland in the Grand Bay Swamp, respectively.

The Fripp-Leon association (9) soils are deep soils along the coast and include beach soils, sand dunes, and low, wet areas between dunes. Fripp soils are deep, excessively drained sands. Leon soils are also composed of sand, but are poorly drained and have a subsurface layer cemented together with organic material. These soils have limited agricultural value and are used mainly for recreation.

The Bayou-Escambia-Harleston association (15) soils have loamy surface layers and subsoils and are formed in marine and fluvial sediments on uplands and terraces. Bayou soils occupy large flat areas that have poorly defined drainage ways. Escambia and Harleston soils occupy slightly higher elevations on gently undulating ridges. Bayou soils have a dark-gray sandy loam surface with light-gray sandy loam or sandy clay loam subsoil. Escambia and Harleston soils both have dark gray to olive fine sandy loam or loam surface layers underlain by yellow, brown, gray, and red loam subsoils. These areas are fair for woodland use. Although some of the area is used for urban development it is poorly suited for it due to excessive wetness.

The Urban Land-Smithton-Benndale association (16) soils occupy the area around the city of Mobile. These are level to gently rolling urban areas interspersed with natural soils having loamy subsoils formed in loamy marine and fluvial sediments on uplands. Urban land has such disturbed soil profiles due to the construction of buildings, roads, and other structures that identification of soils is usually impossible. Smithton soils are poorly drained loamy soils on broad flat areas and along streams; these soils have grayish-brown and brownish-gray fine sandy loam surface overlying brownish-gray fine sandy loam subsoils. Benndale soils are on ridgetops and upper side slopes and are well drained. Benndale soils have dark grayish-brown fine sandy loam topsoil underlain by yellowish-brown or brownish-yellow loam or fine sandy loam subsoils. These areas are mostly urbanized or committed to future urban use, and potential for other uses is poor.

The Southern Pine Hills is a southward sloping plain, moderately dissected by streams, with subdued topography in the study area, although there are sharp bluffs along the northeast shore of Mobile Bay. Along the seaward margin, the escarpment lies parallel to the gulf and Mississippi Sound from which it turns northward and extends inland, forming subparallel facing escarpments that follow the streams (Alabama Coastal Area Board 1978). The Southern Pine Hills subdivision of the Lower Coastal Plain within Baldwin County is underlain by four basic types of shallow subsurface deposits: marine terraces, and the Citronelle, Mobile Clay, and Ecor Rouge Formations (Isphording 1977).

Along the coast, in a strip about 24 km (15 mi) wide, are the marine terraces of sand and clay deposited during Pleistocene times. They meet the Recent coastal sand deposits to the south at elevations of 3 to 7 m (10 to 20 ft), and overlie the older Citronelle formation.

At elevations of about 30 m (100 ft), the Citronelle formation of Plio-Pleistocene age emerges. Predominantly sand, it contains thin layers of red clay which may be mottled gray and purple, red, or yellow, depending upon degree of weathering. The Citronelle formation underlies the plateaus and ridges of north and central Baldwin County, and ranges in elevation from about 30 to 90 m (100 to 300 ft).

The older Ecor Rouge Sand and Mobile Clay, of Miocene age, and older strata support the Citronelle Formation. Varying in thickness from a thin veneer to 60 m (200 ft), the Citronelle Formation is eroded by stream action in many areas to expose the Mobile Clay. As a result of this erosion, the greatest relief in Baldwin County is in areas of Mobile Clay. The clay is white, pink, or purple and contains some sand. Elevation of exposed units of Mobile Clay vary widely from 15 to 90 m (50 to 300 ft).

Areas underlain by the Citronelle Formation and Ecor Rouge Sand in Baldwin County are fairly well associated with soils of the Malbis-Bama-Lucedale (4) and Cowarts-Notcher-Esto (5) associations.

The Malbis-Bama-Lucedale association (4) soils are deep, well-drained loamy soils over wide areas of heavily farmed agricultural uplands. About 75% of this association is currently used as cropland; the rest as pastures and woodland. Malbis soils have dark-gray to brown fine sandy loam surface layers with yellowish-brown sandy clay loam subsoils. Bama soils have dark yellowish-brown fine sandy loam topsoil overlying a yellowish-red sandy clay loam subsoil. Lucedale soils have a dark brown to dark reddish-brown loam surface layer and dark-red sandy clay loam subsoil.

The Cowarts-Notcher-Esto association (5) soils are in upland areas of moderate slope. They are well drained, but not quite as deep as those of the Malbis-Bama-Lucedale association. Although this association has high agricultural potential, most of the land is forested. Cowarts soils have a surface layer of grayish-brown to very dark gray fine sandy loam with a yellowish-brown sandy clay loam subsoil. Notcher soils have a dark grayish-brown fine sandy loam surface layer overlying a yellowish-brown clay loam subsoil containing iron concretions (concretions are grains or nodules of cemented substances, usually yellowish-brown and gray clay loam and calcium carbonate or iron oxide). Soils of the Esto series have a dark grayish-brown fine sandy loam surface layer with sandy clay subsoil.

There is a strong correlation between the Cowarts-Troup-Esto (3) and Troup-Plummer (7) soil associations and areas where streams have eroded through the Citronelle Formation and Ecor Rouge Sands to expose Mobile Clay. The Cowarts-Troup-Esto association is found on the slopes draining into the Mobile Delta, and the Troup-Plummer association is found around several other major streams, particularly tributaries of the Perdido River (Pensacola quadrangle).

Troup soils have a yellowish-brown to dark grayish-brown loamy fine sand overlying a brownish-yellow to red sandy clay loam subsoil. Plummer soils are poorly drained, with little slope, and have a gray sand topsoil overlying a light gray sandy loam subsoil. Cowarts and Esto soils have been discussed

previously. The agricultural potential of the Troup-Plummer association (7) is not great, and most of the area is pine and hardwood woodlands. The Cowarts-Troup-Esto association (3) soils are better suited to woodlands than agriculture.

In Baldwin County, near the coast, there is poor correlation between soil associations and the area underlain by the Pleistocene marine terraces. Although the area is in great part Poarch-Pactolus (8), large portions are also Troup-Plummer (7) and Malbis-Bama-Lucedale (4) association soils. The Poarch-Pactolus association (8) soils are deep, well to somewhat poorly drained, level to very gently sloping soils of uplands. Poarch soils are dark grayish-brown fine sandy loam underlain by olive-yellow to yellowish-brown, mottled loam subsoil. The Pactolus soils have a surface layer of dark grayish-brown loamy sand with a mottled, light yellowish-brown and gray loamy sand substratum (McBride and Burgess 1964).

In Mobile County, there is not as much correlation between soil associations and shallow subsurface geology, at least in the upland Southern Pine Hills. Although the Shubuta-Troup-Benndale association (17) is closely correlated with Miocene deposits and the Troup soil series is in almost all the upland areas underlain by the Citronelle (Plio-Pleistocene) and Miocene deposits, very little additional correlation is noted. The Troup-Benndale-Smithton association (11) is predominant in northern Mobile County, while the Troup-Heidel-Bama association (10) is dominant in southern Mobile County. Notcher-Saucier-Malbis association (14) soils are also found in southern Mobile County, where plinthite is found in the loamy subsoils. Plinthite is a hardened layer in the soil composed of clay and quartz which may form an impervious hardpan layer.

The Notcher-Saucier-Malbis association (14) soils are moderately well drained soils formed in loamy and clayey marine sediments on uplands. Saucier soils are found in flat areas at lower elevations than the Notcher and Malbis soils. The Notcher and Malbis soils are found on broad flat ridgetops. Notcher soils are also found on side slopes and at the heads of drainage ways. All have sandy loam surface layers and the plinthite-containing loamy subsoils. Saucier soils have a dark grayish-brown fine sandy loam surface underlain by yellowish-brown fine sandy loam and loam. Notcher and Malbis soils have been previously discussed. Most of this soil association is used either as cropland or pasture. The slow absorption of water by these soils due to the plinthite layer is their main limitation for residential and urban use.

Troup-Heidel-Bama association (10) soils are found on broad, level, slightly convex ridgetops and slightly steeper slopes next to drainage ways. Heidel and Bama soils are found on the higher flatter areas and have sandy loam surfaces. Troup soils are found on the slightly steeper slopes and have a loamy sand surface. Heidel soils have a dark-brown sandy loam topsoil overlying a yellowish-red to red fine sandy loam subsoil. Bama and Troup soils have already been discussed. All the soils are well drained, have loamy subsoils, and were formed in loamy marine sediments on uplands. Most of this area is cropland and pasture and the potential for urban and woodland uses is good although erosion and the low water capacity of Troup soils is a limitation.

The Troup-Benndale-Smithton soil association (11) is common in the northern parts of Mobile County, which is the portion of greatest relief. Troup soils are found in the areas of greatest slope, Benndale soils in broader areas and gentler side slopes, and Smithton soils in the lower, more poorly drained areas. Benndale and Smithton soils have loamy surface layers, while the Troup soils are thick sandy soils. All three are underlain by loamy subsoils and were formed in loamy marine and fluvial sediments on uplands. Smithton and Benndale and Troup soils have already been discussed. Areas in this association are best utilized as woodland and wildlife habitat, as the slope and wetness limit urban and cropland uses.

The Shubuta-Troup-Benndale association soils are found on rolling, undulating ridgetops and side slopes, as well as the lower areas along several streams in northern Mobile County. They are well drained soils with clayey and loamy subsoils and were formed in clayey and loamy marine sediments on uplands. Troup soils are on lower side slopes and have surfaces of thick loamy sand. Shubuta and Benndale soils are on upper side slopes and ridgetops and have loamy surface layers. Shubuta soils have a dark-brown fine sandy loam surface layer, and a yellowish-red to red clay or clay loam subsoil. Benndale and Troup soils have been described already. These areas are used mostly for woodland because of the short, choppy nature of the slopes and the low water capacity of the Troup soils limiting cropland use (Hickman and Owens 1980).

The percentage of area each soil series occupies within a county and the percentage of area each soil series occupies within each association are presented in Table 18.

The Soil Conservation Service's description of the potential uses of the various soil associations in Mobile County is given in Table 19. Limitations that each association may have for a particular use are also listed. Cultivated crops are those crops extensively grown in the area (e.g., corn, potatoes, soybeans), whereas specialty crops are those that require intensive management (e.g., watermelons, grapes, pecans, green beans). Woodland may refer to either introduced trees (e.g., pecans, other fruit trees, and ornamentals) or those that occur naturally in the area (e.g., longleaf, slash, and loblolly pines, water oaks). Urban includes any residential, commercial, or industrial development. Intensive recreation areas are subject to heavy foot traffic in a concentrated area, such as campsites, ball fields, or picnic areas. Extensive recreation areas are subject to lighter foot traffic over a wider area, such as hiking, nature study, or wilderness.

EROSION AND ACCRETION

The processes that influence the erosion and accretion of Alabama's shoreline are complex and include both natural and human actions. Man has changed the shoreline through dredging and disposal activities, while the natural processes of wind, wave action, tides, currents, severe weather disturbances, sediment budget variations, and sea level changes act daily upon those same shores.

Table 18. Relative percentages of soil types in Baldwin and Mobile Counties, Alabama (McBride and Burgess 1964; Hickman and Owens 1980).

Soil Associations (numbers correspond to those on maps)	Percentage of county	Percentage of association, respectively	Percentage of minor soils
	Baldwin County		
1. Dorovan-Levy-Iuka-Urbo	10	45-14-22	19
2. Annemaine-Wahee-Leaf	3	12-17-5[a]	36
3. Cowarts-Troup-Esto	21	NA-20-NA[b]	50
4. Malbis-Bama-Lucedale	18	20-12-9	59
5. Cowarts-Notcher-Esto	16	13-12-13[c]	NA
6. Axis-Lafitte	3	96[d]	4
7. Troup-Plummer	17	34-15	51
8. Poarch-Pactolis	7	18-17	65
9. Fripp-Leon	5	21-13	66[e]
	Mobile County		
10. Troup-Heidel-Bama	27	34-25-12	29
11. Troup-Benndale-Smithton	31	43-14-6	37
12. Dorovan-Johnston-Levy	9	48-12-12	28
13. Izagora-Bethera-Suffolk	9	34-9-9	48
14. Notcher-Saucier-Malbis	5	37-23-20	20
15. Bayou-Escambia-Harleston	6	31-25-14	30
16. Urban Land-Smithton-Bennedale	5	37-14-8	41
17. Shubuta-Troup-Benndale	5	33-21-20	26
6. Axis-Lafitte	3	44-38	18

[a]an additional 30% mapped as Annemaine-Wahee-Leaf undifferentiated mapping unit.
[b]an additional 30% mapped as Cowarts-Troup-Esto undifferentiated mapping unit.
[c]an unknown percentage of Cowarts-Notcher-Esto mapped as undifferentiated mapping unit.
[d]percent of individual series not available.
[e]includes an additional 10% mapped complex of Fripp and Leon soils and 20% water.
N/A = percentages for individual soil series and minor soils not available.

Quantification of the results of all of these processes is difficult because detailed data over a long period is required. With few exceptions, that level of detailed data is not available. An understanding of the various processes and some quantifications are, however, possible.

The wind affects wave and tidal movements in the Mobile Bay area, and thereby plays an important role in erosion patterns. During the fall and

Table 19. Potential uses and limitations of map units on the general soil maps of Mobile County for specified uses (Hickman and Owens 1980).

Map Unit	Percent of county	Cultivated farm crops	Specialty crops	Woodland	Urban uses	Intensive recreation areas	Extensive recreation areas
10. Troup-Heidel-Bama	27	Good to fair: droughty	Good to fair: droughty	Good	Good	Good to fair: too sandy	Good
11. Troup-Benndale-Smithton	31	Fair to poor: droughty, slope, wetness	Poor: droughty, slope, wetness	Good	Fair to poor: slope, wetness	Fair: slope, too sandy	Good
12. Dorovan-Johnson-Levy	9	Poor: wetness, floods	Poor: wetness, floods	Fair: wetness, floods	Poor: wetness, floods	Poor: wetness floods	Fair: wetness, floods
13. Izagora-Bethera-Suffolk	9	Good to fair: wetness.	Good to fair: wetness.	Good	Poor: wetness, floods	Fair to poor: wetness	Fair: wetness
14. Notcher-Saucier-Malbis	5	Good	Good	Good	Good to fair: wetness, percs slowly	Good	Good
15. Bayou-Escambia-Harleston	6	Fair to poor: wetness	Fair to poor: wetness	Fair: wetness	Poor: wetness	Poor to fair: wetness, percolation slow	Good
16. Urban Land-Smithton-Benndale	5	Poor: small	Poor: small areas	Poor: small areas	Fair: wetness areas	Fair: wetness	Poor: small areas
17. Shubuta-Troup-Benndale	5	Fair: slope, droughty	Fair: slope, droughty	Good	Good to fair: low strength, percolation slow	Fair: slope, percolation slow, too sandy	Good
6. Axis-Lafitte	3	Poor: wetness, floods	Poor: wetness, floods.	Poor: floods, wetness	Poor: wetness, floods.	Poor: wetness, floods	Fair: wetness, floods

winter winds are predominantly from the north or northwest, while spring and summer winds are from the south or southwest (Chermock 1974).

Persistent high winds from the north and northwest during the winter tend to depress the water level in much of the bay and concurrently cause a buildup of waves along the south and southeast shores where wind fetch length is great. Under these conditions, severe erosion may occur along the northern shore of Morgan Peninsula (Pensacola quadrangle) (Figure 7).

During the summer and occasionally in the winter persistent strong south and southwesterly winds (13-28 km/hr, 8-17 mi/hr) cause a decrease in water level, especially in the lower bay. Waves and tides then build up in the upper bay, causing severe erosion along the western shore and lower Mobile Delta (Mobile quadrangle). These variations in water level cause complex currents that complicate the normal circulation within the bay.

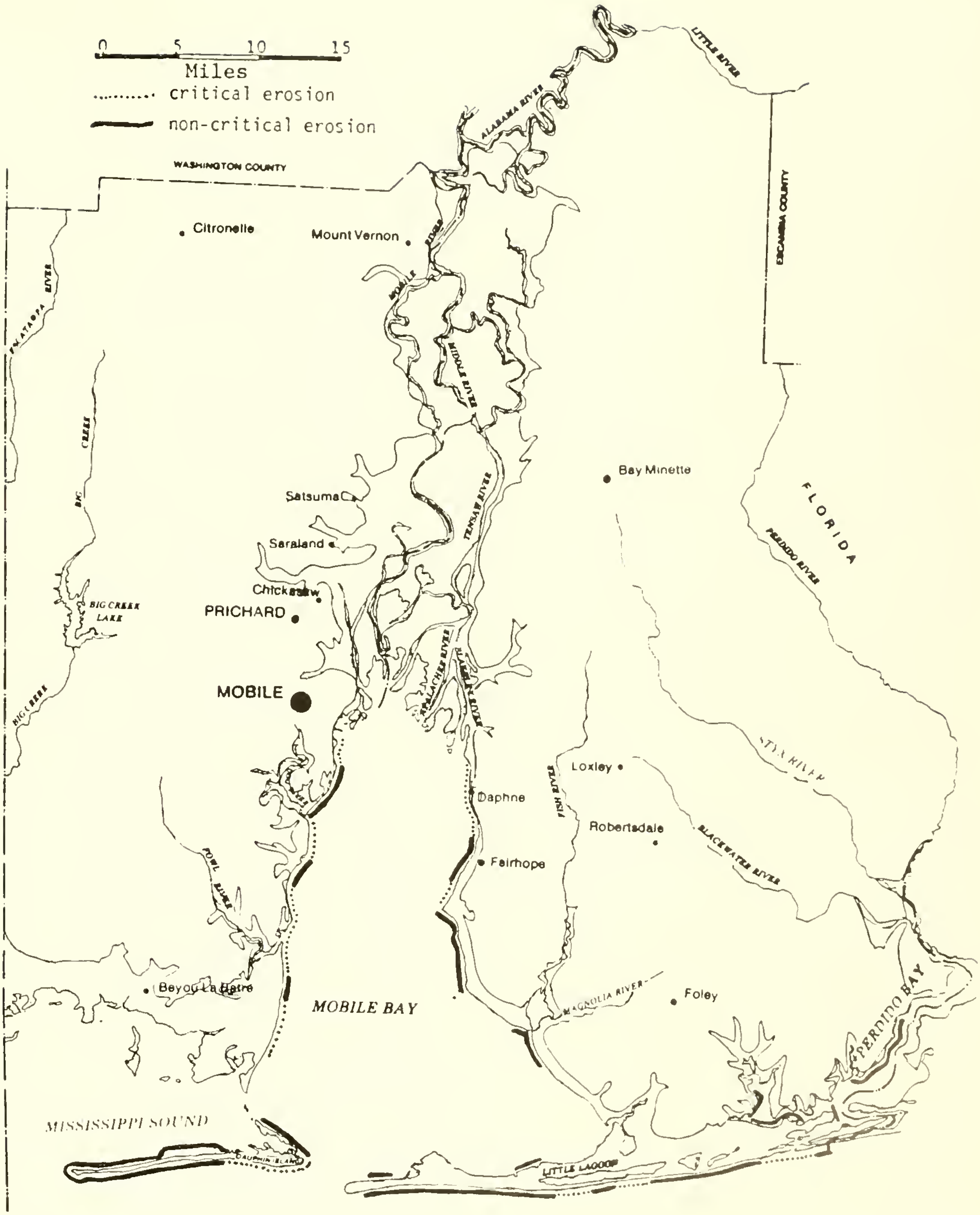

Figure 7. Erosion areas in coastal Alabama (U.S. Army Corps of Engineers 1971).

Somewhat the same situation exists in Perdido Bay (Pensacola quadrangle), although erosion effects are not as pronounced because of the bay's smaller size (Hardin et al. 1976).

The aspects of severe weather disturbances that cause the greatest changes to shorelines and near-shore bottoms are storm surges, waves, and currents (Hayes 1967). Since much of the shoreline of Alabama is below 3 m (10 ft) in elevation there is great erosional danger from a hurricane storm surge. When a storm surge advances up a converging estuary such as Mobile or Perdido Bays, its height increases as the water becomes more confined. The storm surge progresses more rapidly on a rising tide and may form a wall-like wave of water moving up the estuary (Chermock 1974).

By far the most significant event in terms of shoreline erosion took place in September 1979, Hurricane Frederic, which caused massive shoreline changes.

In Baldwin County immediately west of Perdido Bay (Pensacola quadrangle) the shoreline receded about 24 m (80 ft), and for about the next 19.3 km (12 mi) west to the vicinity of Little Lagoon (Pensacola quadrangle), about 30 m (100 ft). All along the Fort Morgan Peninsula (Pensacola quadrangle), extensive dune erosion took place.

In Mobile County, Dauphin Island (Biloxi quadrangle) was overwashed along the entire 17.7 km (11 mi) long western end. All the low areas on the eastern portion of the island were flooded and the southern shoreline receded from 3 to 30 m (10-100 ft). Along the western end of the island, the southern shore receded about 6 to 15 m (20-50 ft) and the entire spit was lowered from an elevation of 1.5 to 3 m (5 to 10 ft); National Geodetic Vertical Datum (NGVD) to an elevation of 0.6 to 1.5 m (2 to 5 ft) (U.S. Army Corps of Engineers 1981).

The following information on sediment budget variations is from Hardin et al. (1976).

> The sediment budget for the coastal system is the net amount of sediment in the coastal area after considering the quantity of material being introduced, the quantity temporarily stored (dunes), and the quantity being removed from the coastal system. Beaches are nourished and maintained by sand-size sediment contributed by major streams, updrift shoreline erosion, onshore movement of shelf sand by wave action (Brown, and others, 1974), and by current circulation. Sand losses are caused by transportation offshore into deep water, accretion along and against natural barriers and man-made structures, deposition in tidal deltas and hurricane washover fans, excavation for proposed construction, and eolian processes (Brown et al. 1974).

Sediment is carried to coastal Alabama by the Mobile and Perdido River systems. No data on the quantity of suspended sediment transported by the Perdido River is currently available (Boone 1973). Suspended sediment load transported yearly by the Mobile River into the delta and bay system ranges from 1.9 million to 7.5 million metric tons (2.1 million to 8.3 million short

tons) and averages 4.3 million metric tons (4.7 million short tons). About 30% (1.3 million metric tons, 1.4 million short tons) of this passes through the estuary system to the Gulf of Mexico (Ryan 1969).

Longshore drift brings a volume of sediment, especially sand, into the Alabama coastal zone. The south and southeast winds cause westward-flowing currents, bringing sediment from the Florida coast into Alabama. The Mobile Bay discharge is a major drift barrier, and much of the westward-moving sediment is carried offshore. Net longshore drift has been measured at Perdido Pass (Pensacola quadrangle) to be 49,699 m^3 (65,000 yd^3). Net longshore drift at Gulf Shores (Pensacola quadrangle) has been calculated to be 149,853 m^3 (196,000 yd^3) by D. S. Gorsline, using wave-energy calculations (U.S. Army Corps of Engineers 1973a).

> These examples give only brief glimpses of a complex sediment budget. Obviously, much work needs to be done on the variations in movement and the fate of sediments within the coastal system of Alabama (Hardin et al. 1976).

Hardin et al. (1976) examined the question of sea-level changes and how this process affects shoreline erosion and accretion, noting that while the National Ocean Survey established 16 control tide stations along the gulf coast to determine the changes taking place in the relative elevations of land and sea, none of these stations is located in Alabama. Based on data gathered over the past 50 years along the Florida gulf coast, a subsidence rate of 0.1 mm (0.04 inch) per year was assigned to the lands of the gulf coast from the Mississippi River to Key West, Florida (Lazarus 1965). Bird (1969) cites recent tidal gauge records that indicated continuing changes in the relative position of the land and sea. In areas such as coastal Alabama which has so much low-lying land, this factor of sea level takes on major significance in regard to shoreline configuration.

Measuring the shoreline of Alabama has proven to be a formidable task. Using conventional opisometry (manually measuring distances on maps using a calibrated wheel), four agencies have arrived at different figures.

The U.S. Army Corps of Engineers reported the estuary shoreline length at 491.2 km (305.3 mi) in Appendix E of the National Shoreline study. The Alabama Department of Conservation listed the correct length as 577.5 km (358.9 mi). The National Oceanic and Atmospheric Administration stated the length of tidal shoreline in Alabama is 976 km (607 mi). Using an opisometer on large scale maps, the Geological Survey of Alabama obtained a figure of 811.3 km (504.2 mi).

> "These measurements are based on traditional map analysis techniques and the difference between them manifests the difficulty encountered in such measurements, including the definition of the parameter being measured" (Hardin et al. 1976).

The newest sources of shoreline data are the NASA satellites Landsat 1 and 2. Satellite data from 28 December 1972 and 5 December 1973 were compared and analyzed. While only part of the shoreline of Alabama was measured

due to limitations of Landsat coverage, the Geological Survey of Alabama did derive an estimate of the total shoreline based on the application of a ratio obtained through conventional opisometer techniques. If the total length of Alabama's shoreline were measured by a NASA land/water interface technique, it would total approximately 1,314 km (816 mi).

In February 1982, as part of the preparation of this atlas, an aerial survey was made of Mobile Bay and its environs to note areas of active erosion. It is these areas that have been shown on the 1:100,000 soils and landforms maps. While there is a reasonable amount of historical data on coastal erosion, only current data is shown on the maps to direct users' attention to the most active areas. The historical trend maps that follow are, however, detailed and informative.

An interesting map published by the Geological Survey of Alabama is entitled "Historical Trends of Shoreline Changes, Alabama Coastal Area, 1917-1974" (Figure 8). This map, although small in scale, contains information compiled from records from 1917 and from 1956-74. When this map was drawn (1974), the shoreline was measured (by opisometer) as 811.4 km (503.9 mi) long. The shoreline showed a net erosional trend of 355.7 km (220.9 mi) and net accretional trend of 455.7 km (283.0 mi), which equaled an approximate net state of equilibrium (Hardin, et al. 1976).

Because several areas around Mobile Bay are more actively eroding than others, the "Historical Trends" map (Figure 8) divides the surrounding lands into nine regions so that more detailed information can be presented. Consult the Hardin et al. (1976) study for 34 pages of detailed maps, trend tables, and graphs keyed specifically to the regions depicted on Figure 8. A brief overview of each of these regions, based on Hardin et al. (1976), follows.

1. Mobile Delta Region (Mobile quadrangle): Over the past 3,000 years, this prograding (accreting) delta has filled in excess of 64 km (40 mi) of the original estuary. The harbor (lower) portion of the delta region has been affected by dredging and landfill and consequently is treated as a separate region.

Between 1917 and 1967, the shoreline of the Mobile Delta has shown a trend toward net erosion although a few areas exhibit a state of equilibrium. Erosion has occurred principally along the channel margins of distributary rivers such as the western bank of the Blakeley River, the eastern bank of the Apalachee River, and along areas of both banks of the Tensaw and Spanish Rivers. Most of the accretion has occurred within the interdistributary bays and along the remaining banks of the distributaries. The tips of the natural levees marginal to the distributaries show both erosion and accretion. Between 1953 and 1967, there was a distinct erosional trend in all the interdistributary bays, which reverses the accretional trend of the past 36 years.

Between 1917 and 1967, a net loss of 8.92 ha (22.04 acres) of area occurred in the Mobile Delta. In an environment where sediment deposition and land-building might be expected, such a loss indicates that the delta's progradation has decelerated. Such a situation might be partly caused by a

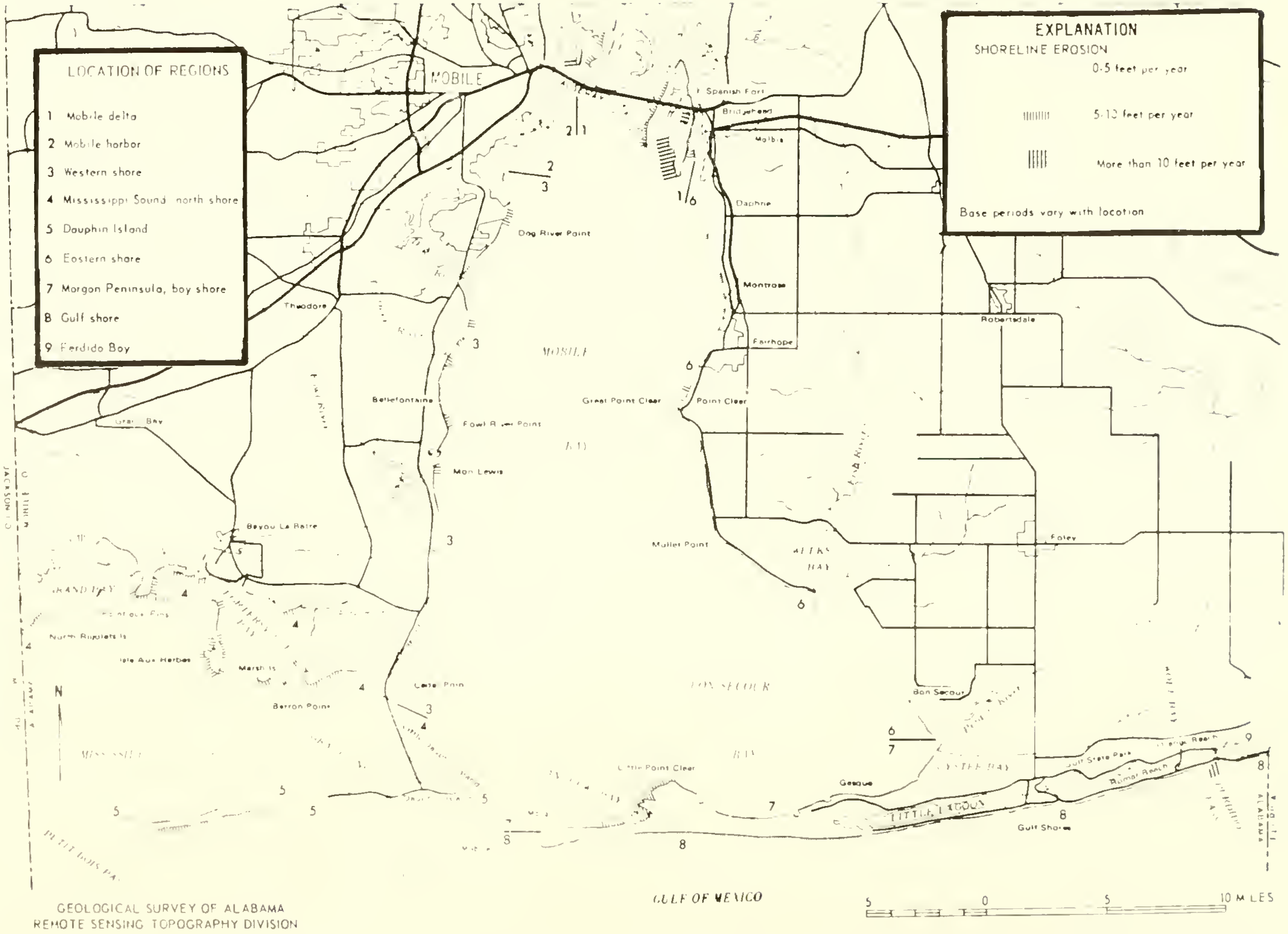

Figure 8. Historic trends of shoreline changes, Alabama coastal area 1917-74 (Hardin et al. 1976).

decrease in sediment being transported downstream by the Mobile River as a result of upstream impoundments, or by short periods of high discharge (floods). The greatly increased velocity of water flowing over the delta during such floods could cause much erosion in a short period.

2. Mobile Harbor Region (Mobile quadrangle): The main cause of accretion in this region has been human disposal activities as opposed to natural processes. This region will be discussed in the chapter dealing with socioeconomic features, under the category of artificially-made lands.

3. Western Shore Region (Mobile quadrangle): This region of Mobile Bay shows signs of erosion for almost its entire north-south distance. Between 1917 and 1974, erosion has ranged from 12 m (39 ft) at Pt. Judith to 149 m (488 ft) at Cedar Point. The areas between Dog River Point and Fowl River Point and between Delchamps Bayou and Cedar Point show the most severe erosion (Figure 1).

4. Mississippi Sound, North Shore (Biloxi quadrangle): The northern shoreline of Mississippi Sound in Alabama is mostly made up of low-lying salt marsh with numerous tidal creeks and, with the exception of some residential and commercial-fisheries development, remains in its natural state. The southern shoreline is composed of sandy barrier islands that protect the northern marshy coast from the full impact of erosional agents, such as wave action and tropical storms.

Between 1917 and 1958 the northern shore experienced net shoreline erosion at selected points which varied from 47.8 m (157 ft) on Marsh Island (Grand Bay) to 132.2 m (434 ft) on Marsh Island (Portersville Bay). These represent erosional rates ranging from 1.2 m (3.8 ft) to 3.2 m (10.6 ft) per year for those specific points. The generalized areas of erosion for eastern Mississippi Sound are shown on Figure 8. Most erosion has occurred on exposed marshy headlands and on exposed shorelines of the offshore islands. It was estimated (1976) that many of the exposed shorelines in this region are eroding at an average rate of 1 to 2 m (3 to 7 ft) per year.

5. Dauphin Island Area (Biloxi quadrangle): Dauphin Island is part of a chain of barrier islands protecting Mississippi Sound from the erosional forces of the Gulf of Mexico. These barrier islands absorb almost the full impact of winds, wave action, tides, and currents. As with all other islands of this type, the Dauphin Island shoreline is constantly changing. Several times since 1917, and as recently as 1979 (Hurricane Frederic), the island has been overwashed as a result of severe weather.

There has been a general trend of erosion along the gulf shore of the island and a general elongation of the western end of the island. Shoreline erosion on the entire gulf shore for the period 1942-74 averaged 63.7 m (209 ft) or 1.9 m (6.3 ft) linearly per year excluding accretion on the western tip of the island. This accretion added a total of 2.9 km (1.8 mi) to the length of Dauphin Island from 1917 to 1974.

6. Eastern Shore Region (Pensacola quadrangle): Most of this region has undergone accretion or has maintained a state of dynamic equilibrium between

1917 and 1967 or 1974. (Period of record depends upon the particular portion of shore in question.) Erosion along the eastern shore occurs intermittently and is of less magnitude than in most other areas in the region.

7. Morgan Peninsula, Bay Shore (Pensacola quadrangle): Morgan Point is a large baymouth bar extending westward from the eastern shore of Mobile Bay. This peninsula separates the bay water from the gulf water and insures the maintenance of the estuarine environment in the bay itself. Erosion, measurable along much of the northern shore, probably occurs along almost the entire length of the shore from the mouth of Bon Secour River to Fort Morgan. Measurements of the change in shoreline configuration between 1917 and 1974 show that as much as 52 m (170 ft) linearly of erosion may have occurred from the mouth of Bon Secour River to Catlins Bayou during that time.

Examination of bathymetric data from 1929 to 1973 reveals that St. Andrews Bay, Navy Cove, and the bay north of Fort Morgan are becoming progressively shallower. The southwest cove of St. Andrews Bay has also become a shoal area, probably reflecting deposition of material eroded from the shoreline west of Little Point Clear, as well as material from the spoil banks northwest of the peninsula along the Mobile Ship Channel.

8. Gulf Shore Region (Pensacola quadrangle): The gulf shore region of coastal Alabama extends from Mobile Point to the Florida state line and is about 50 km (32 mi) in length. The shoreline of white sandy beaches is backed by low dunes.

In 1917, there were several tidal inlets that opened into Little Lagoon and Shelby Lakes. The inlet connecting Little Lagoon to the gulf was 1.1 km (0.7 mi) west of Gulf Shores beach and was approximately 80 m (262 ft) wide. A second inlet was approximately 1.7 km (1.1 mi) west of Romar Beach, as located on the Foley, Alabama, U.S. Geological Survey 15 min topographic map. This inlet connected the easternmost lagoon on the Shelby Lakes with the gulf and was approximately 20 m (66 ft) wide. By 1941, both of these inlets had closed and a second inlet to Little Lagoon had opened. This inlet, 3.5 km (2.2 mi) west of the inlet of 1917, was about 60 m (197 ft) wide. High-altitude infrared photographs of this area taken in 1974 showed no passes open into either Little Lagoon or Shelby Lakes, although some water possibly flows through the western inlet of Little Lagoon at the highest high tide.

Between 1917 and 1974, the gulf shore eroded by an average of 0.4 m/yr (1.4 ft/yr) between Fort Morgan and Alabama Point. This net erosion along the gulf shore occurred in the areas indicated on Figure 8.

9. Perdido Bay Region (Pensacola quadrangle): Perdido Bay itself has shown little measurable change along the Alabama shoreline, according to presently (1976) available information. Areas of small amounts of erosion probably do exist within Perdido Bay, but are too small to be discerned by methods used in the Hardin et al. (1976) study. Significant changes in the configuration of Perdido Bay have occurred in the area of Perdido Pass.

Changes in Perdido Pass are among the most extensive identified in this study. In 1867 the Perdido River channel (now called Old River) flowed around the east end of Ono Peninsula (now Ono Island), then westward to enter the gulf. By 1890-1892, this river channel had been partly abandoned and the major flow from Perdido Bay entered the gulf through a channel in Ono Peninsula excavated by local residents between 1867 and 1892 (U.S. Army Corps of Engineers 1973a). By 1918, water exchange occurred through two inlets separated by an island. This configuration may have been caused by the hurricane of 8 September 1917. Gradually the accretion resulting from the westward littoral drift closed these two inlets to form a single inlet by 1941. Between 1941 and 1974, persistent littoral drift had caused the pass to migrate westward until arrested by the construction of a seawall in the 1960's. The pass in its natural state was about 1.8 m (6 ft) deep and presented great hazard to navigation (Ryan 1969). Safe navigation has been assured by the construction of several seawalls, which stabilized the pass and protected a bridge over the inlet. Further migration of the inlet is unlikely; however, past experience suggests that a severe disturbance, such as a direct blow from a hurricane, could breach the island again. The most recent severe hurricane was Frederic in September 1979. While much of the land area west of Perdido Pass east to the Florida state line was overwashed, there was no permanent breach that would link the gulf with Old River to create a new pass.

The U.S. Army Corps of Engineers (1971) classified the shores of Mobile and Baldwin Counties, Alabama, into three categories: non-eroding, eroding, and critically eroding. Their inventory reveals that of approximately 566 km (352 mi) of Alabama shoreline, 182.6 km (113.5 mi) are experiencing non-critical erosion and almost 53 km (33 mi) are experiencing critical erosion (Figure 8). Critical erosion is so defined either because of the speed of shoreline recession or because of potential impact on people's structures. This classification is based on observed responses to normal conditions and cannot be used to predict changes occurring under abnormal conditions. As an example, observation of Figure 8 identifies the southeast shore of Dauphin Island as an area experiencing critical erosion. Between 1901 and 1917, hurricane surge and associated waves breached Dauphin Island, dividing it into two small islands separated by 8.5 km (5.3 mi) of open water, shoals, and scattered remnants of the former island. Between 1917 and 1942, the inlet was filled by natural processes. A less severe breach occurred during the 4 September 1948 hurricane. When Hurricane Frederic hit the island in 1979, an area to the west of the designated area of critical erosion was washed over, but the island was not severed. To predict damage to coastal areas, storm conditions, as well as normal sea and weather, must be taken into account. The most reliable information available to predict the effect of storms is historical data, but neither meteorological events nor their effects can be predicted with much reliability (U.S. Army Corps of Engineers et al. 1981).

GEOLOGIC FAULTS

The faults that are shown on the 1:100,000 maps are marked as to their upthrown and downthrown sides. These terms refer to the block or mass of rock

on that side of a fault which has been displaced relatively and not absolutely upward or downward.

Geologic faults in Mobile and Baldwin Counties are the result of irregularities in Cretaceous and Tertiary deposits, which are caused by movement of the underlying Louann Salt. In fact, some of the peripheral faults in north Baldwin County may represent salt movements on the very edge of the Mississippi interior salt dome basin. Salt under great pressure (i.e., at great depths below the surface) behaves as a plastic substance and moves in response to sedimentary loading. Positive features, such as salt swells and domes and collapse-type features such as grabens where salt was displaced and overlying rock receded, are both found in the study area. Positive features in Mobile and Baldwin Counties include the Citronelle and Wiggins uplifts. The major fault features include the Mobile graben and the peripheral faults associated with the Pollard fault zone.

Although there are several faults in the area, the probability of damage from an earthquake is extremely unlikely. The U.S. Coast and Geodetic Survey ranks all areas of the United States in regard to the possibility of damage from earthquakes on an arbitrary scale of 0 to 3. These rankings are based on the intensity of possible earthquakes and anticipated damage, but not their frequency. These rankings are based on historical data and are revised as damaging earthquakes occur. Coastal Alabama lies in Zone 0:

Zone 0 - no damage
Zone 1 - minor damage
Zone 2 - moderate damage
Zone 3 - major damage

Because coastal Alabama has had no damaging earthquakes (as of October 1982) since the rankings were first compiled in 1948, its ranking has remained unchanged (Algermissen 1969).

Although a significant earthquake originating in Alabama is unlikely, there is a slight possibility that powerful, low-frequency tremors originating at a distance (e.g., Louisiana has regular tremors) could cause damage in the study area. Buildings in the Mobile area could suffer liquifaction of their supporting soil, particularly if they are built on fluvial sediments. As most of the structures in the study area are probably reinforced to withstand wind stress from hurricanes, they could probably withstand any likely earthquake tremor (D. Perkins, National Earthquake Information Center, Boulder, CO, 15 September 1982; pers. comm.).

A complex of peripheral faults running across southwest Alabama includes the Pollard fault zone on the northern edge of Baldwin County. Faults connected to this complex curve through Florida and reappear in southern Baldwin County. The faulting in this complex has resulted in a series of narrow grabens, and subsequent faulting occurred between the two major faults. The northern fault is the dominant one and is downthrown to the southwest. Fault zones can be detected in this area only by subsurface indications (such as well log data and sonic testing) or very subtle surface indications. Vertical displacement of the fault surfaces ranges from 30 to

60 m (100 to 200 ft), and some of the fault movement has occurred recently enough for the grabens to appear as topographic lows.

The Mobile graben is a complex north-south fault system running from Jackson, Alabama, south to Mobile Bay. The northernmost fault on the east flank of the graben system is the Jackson fault. The confluence of the Alabama and Tombigbee Rivers and the formation of Mobile Bay is possibly the result of movement along faults within this system (Chermock 1974).

Many features of the graben are poorly known.

> "The major fault representing the west flank of the graben opposite the Jackson fault has never been penetrated. Geologists have postulated its location on the basis of subsurface data but other interpretations are possible for the data" (Chermock 1974).

Both the east and west flanks of the graben can be mapped further to the south, although a relationship between the graben and Mobile Bay is not obvious. According to well-control data, the graben turns westward north of the bay and extends to northern Mobile County. To quote Chermock (1974) again,

> "The Mobile graben system has been a highly mobile fault zone since at least late Mesozoic time, and many structures favorable for petroleum accumulation have been formed."

ACTIVE DUNES

For the purposes of this atlas, active dunes are defined as those sand landforms influenced by wave action and/or eolian (wind) processes that are in a constant state of change. Typically these dunes support little or no stabilizing vegetation.

On the 1:100,000 study maps, areas where active dunes occur have been appropriately marked. The location of individual dunes that can be considered currently active is beyond the scale of the atlas maps, although as a generality the actual number of dunes that are active is small. Those that are most active are scattered along the gulf side of the western end of Mobile Point-Fort Morgan Peninsula (Pensacola quadrangle). A detailed assessment of dunes in both Mobile and Baldwin Counties was undertaken by the U.S. Army (U.S. Army Corps of Engineers 1981) as part of the report of damage of Hurricane Frederic in 1979. While the report does not deal specifically with active dunes, it does contain a good description of the existing dunes as they appeared after the hurricane.

In Baldwin County for a distance of about 6 mi along the beach west from Perdido Bay (Pensacola quadrangle), the dunes were eroded from approximately 3 m (10 ft) in elevation vertically down to 1.5 m (5 ft). From Little Lagoon (Pensacola quadrangle) west for about 10 km (6 mi) the dunes that had averaged 4.5 to 6 m (15 to 20 ft) in height were eroded approximately 3 m (10 ft) vertically. For the next 8 km (5 mi) west, to Fort Morgan at Mobile

Point (Biloxi quadrangle), dunes that had been 4.5 to 6 m (15 to 20 ft) NGVD were eroded to 1.5 m (5 ft) NGVD.

On Dauphin Island (Biloxi quadrangle) in Mobile County, the south side of the island, fronting the gulf, has a broad, well-developed beach and sand dunes that rise to 12 m (40 ft) NGVD.

The atlas maps delineate where dunes of any description are found within the study area. In order to map the exact location of those few truly active dunes, a new large-scale mapping exercise would have to be undertaken.

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Reed, P. C. 1971a. Geology of Mobile County, Alabama. Geol. Surv. of Ala. Map 93.

Five-page narrative with geologic cross-sections and an accompanying color map of county at a scale of 1 inch = 2 mi.

Reed, P. C. 1971b. Geology of Baldwin County, Alabama. Geol. Surv. of Ala. Map 94.

Nine-page narrative with geologic cross-sections and an accompanying color map of county at a scale of 1 inch = 2 mi.

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Contains multicolored maps of the entire State at 1:250,000 scale. Topics include geomorphology, coastal processes, soils, and biological and cultural information.

Beach Erosion and Accretion Areas

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Research Planning Institute overflight aerial photography of February 1982.

Geologic Faults

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Contains a physiographic provinces map and description of the Southern Pine Hills as well as diagrams of faults, domes, and other geologic features.

Moore, D. B. 1971. Subsurface geology of southwest Alabama. Geol. Surv. of Ala. Bull. 99.

Contains information on general stratigraphy and major subsurface geologic structures. Attached in pocket are 11 color maps detailing structure of Alabama oil fields.

O'Neil, P. E., and M. F. Mettee. 1982. Alabama coastal region ecological characterization. Vol. 2. A synthesis of environmental data. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-82/42. 346 pp.

Contains detailed analysis of the minerals, hydrology, geology, climate, flora, and fauna of coastal Alabama. Has detailed descriptions of the area with maps and conceptual models.

Active Dunes

Alabama Coastal Area Board. 1978. Alabama coastal area management program: a balanced approach to economic development and natural resource protection (workshop draft). (Alabama Coastal Area Board) Daphne.

Contains discussion of coastal issues and descriptions with maps of the biophysical, socioeconomic, and natural resources of coastal Alabama, including short discussion of dune size, extent, and stabilization.

Hardin, J. D., C. D. Sapp, J. L. Emplaincourt, and K. E. Richter. 1976. Shoreline and bathymetric changes in the coastal area of Alabama. Geol. Surv. of Ala. Inf. Ser. 50.

Contains map and narrative explanation of coastal shoreline changes.

National Aeronautics and Space Administration. November 1979. False-color infrared aerial photography. Scale 1:62,500.

Research Planning Institute overflight aerial photography of February 1982.

OIL, GAS, AND MINERALS

INTRODUCTION

The oil, gas, and mineral section provides information on these activities in coastal Alabama and includes pipeline routes, refineries, and drilling sites. The location of other significant deposits of minerals such as clay and gravel are also discussed.

OIL AND GAS

Petroleum-related activities in Alabama began in the early 1900's with the discovery of small, shallow gas fields in Huntsville (Madison Co.) and Fayette (Fayette Co.) in northern Alabama, and Mobile in southern Alabama. Located near the Bascomb race track, the two Mobile wells produced over 990 m^3 or 35,000 ft^3 of gas per day (Jones 1926, Masingill and Hall 1979).

After more than 700 dry holes were drilled, the first significant oil discovery in Alabama was made in 1944 near Gilbertown in Choctaw County in the Selma and Eutaw Formations (Upper Cretaceous) (Cretaceous period: 135 million to 65 million years before present) between 785 and 788 meters (m) (2,575 and 2,585 ft) below land surface (Masingill and Hall 1979). The Gilbertown Field produced 12.1 million barrels (bbl) of oil between 1944 and June 1982 (Alabama State Oil and Gas Board 1982). The geologic strata underlying southwest Alabama, with an indication of which strata are important in petroleum production, are shown in Figure 9.

Oil was found in 1950 in the South Carlton Field (Atmore quadrangle) of northern Baldwin County, followed by similar discoveries in adjacent Escambia County. These wells produce from the Lower Tuscaloosa Formation (Upper Cretaceous) at depths of about 1676 m (5,500 ft). The South Carlton Field includes about 50 wells in Baldwin and Clarke Counties, with the majority in Baldwin (O'Neil and Mettee 1982). Between 1950 and 1982 the South Carlton Field produced about 5.0 million bbl of oil (Alabama State Oil and Gas Board 1982). Oil production in South Carlton Field has remained high because of new wells being drilled, even though the field is becoming depleted (Friend et al. 1981).

One of the largest oil resources east of the Mississippi River was discovered in 1955 at Citronelle in northern Mobile County, at depths ranging from 3,052 to 3,300 m (10,014 to 10,827 ft) in the Lower Cretaceous Formation. The Citronelle Field (Citronelle quadrangle) has produced 135 million bbl of oil and 345 billion m^3 (12.2 trillon ft^3) of gas from its 447 producing wells (O'Neil and Mettee 1982, Friend et al. 1981, Alabama State Oil and

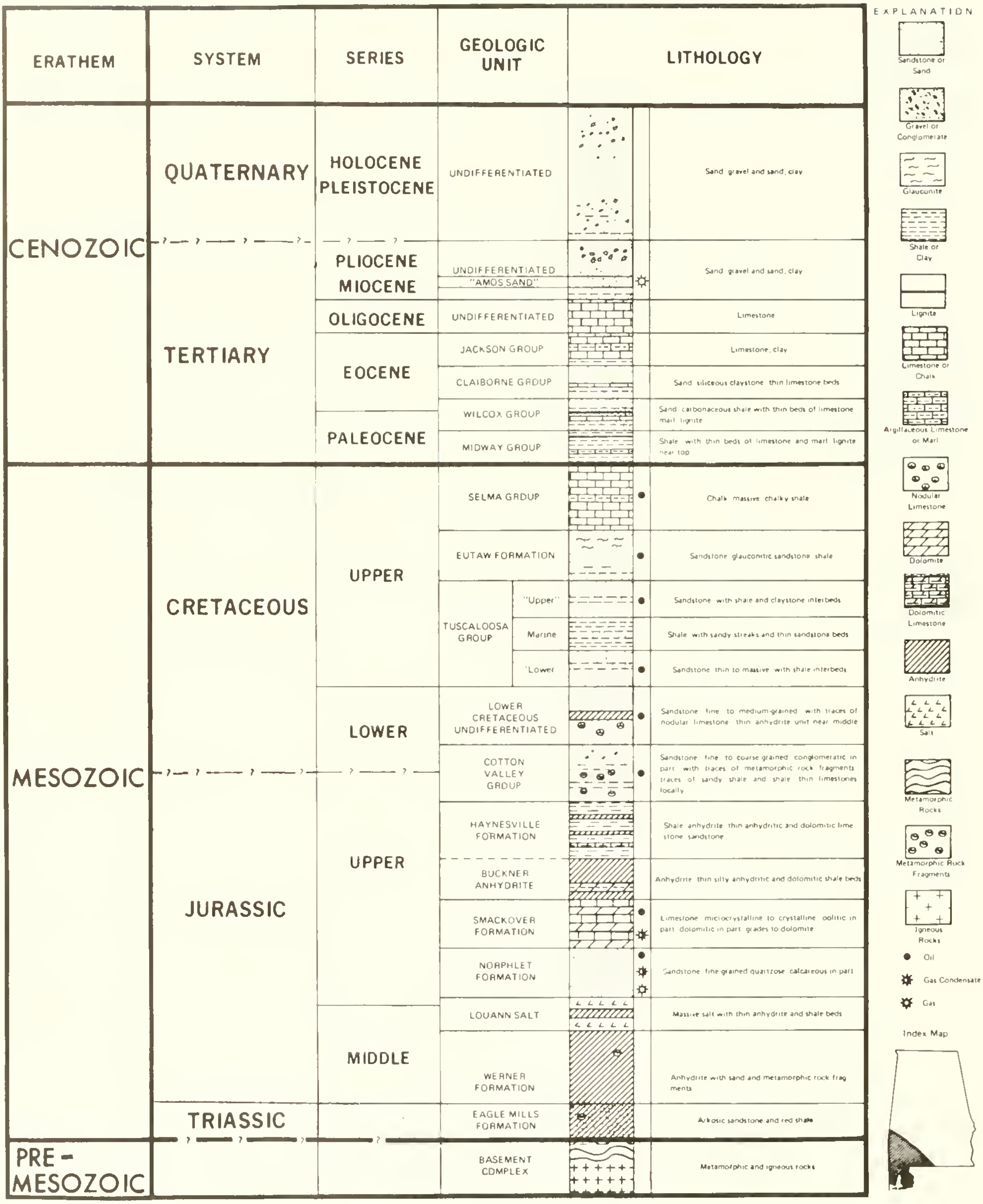

Figure 9. Generalized stratigraphic column in oil- and gas-producing areas in southwest Alabama (Masingill 1982a).

Gas Board 1982). Citronelle has been the state's largest oil producing field since its discovery, accounting for over 30% of Alabama's production.

Over half of the natural gas produced from the Citronelle Field is used in the operation of the production facilities at that location. In 1977, 44,937 bbl of gasoline and 58,202 bbl of butane were extracted from the natural gas by a liquid extraction plant in Citronelle (Alabama Coastal Area Board and U.S. Dept. of Commerce 1979). The plant, operated by Cities Service, was dismantled in about 1980 (D. Kemp, Cities Service Oil Co., Tulsa, OK, 10 August 1982; pers. comm.)

Engineers predict that 146 million bbl of oil will have been removed from the Citronelle Field by 1985, which is 39% of the original total reserves. Studies have indicated that the life of the field could be increased another 25 or 30 years beyond 1985, and another 100 million bbl of oil produced by implementation of an enhanced oil recovery system (Alabama Coastal Area Board and U.S. Dept. of Commerce 1979). A tertiary enhanced recovery program has since been implemented (R. Raymond, Geological Survey of Alabama, University, AL, 15 March 1982; pers. comm.). A tertiary enchanced recovery system is a method whereby nitrogen gas is pumped underground to force oil to the surface and increase the cumulative yield from the reservoir. Most of the oil produced in Citronelle is transported to storage and refinery facilities in Mobile and then barged to market (Alabama Coastal Area Board and U.S. Dept. of Commerce 1979).

Oil discoveries in northern Baldwin County in 1965 resulted in the designation of Tensaw Lake Field (Atmore quadrangle). Although it has since been abandoned due to production problems, this field was the first significant discovery in the area in over 10 years, and it was the first from the Paluxy Formation (Lower Cretaceous), at about a 2,562 m (8,400 ft) depth. Between 1965 and 1972 this field produced 164,786 bbl of oil (Masingill and Hall 1979).

The Tensaw Lake Field generated a great deal of interest because the initial production was water free and highly pressurized, enough to transport the oil to surface production facilities. It was forecast that as many as 50 wells would need to be drilled in order to efficiently drain the reserve. Subsequent wells, however, showed that the pressure was insufficient to push the viscous oil to the surface. Pumping was necessary to extract the oil, which increased the amount of accompanying saline water. Although the Tensaw Lake Field was abandoned in 1972, increased petroleum prices may cause its revitalization (Alabama Coastal Area Board and U.S. Dept. of Commerce 1979).

The first Jurassic (Jurassic period: 180 million to 135 million years before present) production in Alabama, in the Smackover Formation of Choctaw County and in the Norphlet Formation of Escambia County, paved the way for the Chunchula and Hatter's Pond (Mobile quadrangle) discoveries in northern Mobile County. At depths of about 5,486 m (18,000 ft), the Chunchula Field produces from the Smackover Formation, while the Hatters Pond Field produces from both the Smackover and Norphlet Formations (Masingill and Hall 1979). These finds were made in 1974, but production did not begin until 1976, as a cleansing plant had to be built to separate hydrogen sulfide from the hydro-

carbon component of the production. After the initial discoveries, drilling proceeded rapidly to determine the volume of the petroleum deposits. It appears that these gas reserves will be drained in 15 to 20 years (Alabama Coastal Area Board and U.S. Dept. of Commerce 1979).

Chunchula Field produced 91,088 million m^3 (3,216,403 million ft^3) and 1,501,335 bbl of condensate from 27 wells in 1977. Hatter's Pond Field produced 127,247 million m^3 (4,493,177 million ft^3) and 1,287,989 bbl of condensate from 11 wells in 1977 (Alabama Coastal Area Board and U.S. Dept. of Commerce 1979). Chunchula Field had increased to 35 producing wells by 1982, while the number of wells in Hatter's Pond Field increased to 12. Chunchula's cumulative production as of June 1982 was 17.9 million bbl of condensate and 1.2 trillion m^3 (42.5 trillion ft^3) of gas. Hatter's Pond cumulative production as of June 1982 was 12.2 million bbl of condensate and 1.3 trillion m^3 (47.4 trillion ft^3) of gas (Masingill and McAnnally 1980, Alabama State Oil and Gas Board 1982).

Chunchula and Hatter's Pond are the primary gas condensate producing areas in Mobile and Baldwin Counties. Gas condensate exists in a gaseous state underground, but is recovered as a liquid as a result of reduced pressure or temperature when it reaches the surface (Friend et al. 1981). This liquid is a light oil, much lighter than crude oil.

Chunchula Field has one injection well and Hatter's Pond two injection wells, which are used for the disposal of plant effluents and saltwater that is produced with the hydrocarbons. These wells are regulated by both the Alabama Water Improvement Commission, which regulates the disposal of plant effluents, and the State Oil and Gas Board, which regulates disposal wells associated with oil and gas operations (Alabama Coastal Area Board and U.S. Dept. of Commerce 1981). Chunchula Field has a tertiary recovery system which is expected to increase the recoverable reserves by 38.4 million bbl of condensate, 3.8 million m^3 (134 billion ft^3) of gas, and 1,320 million liters (349 million gallons) of liquid petroleum gas (LPG) (Hellmich 1980).

Immediately to the east of the Chunchula Field, two new fields have been designated: Cold Creek Field and South Cold Creek Field (Mobile quadrangle), with 2 wells and 1 well, respectively. Unlike wells in adjacent Chunchula Field, these wells produce oil rather than gas condensate. They produce from the Smackover Formation at depths of about 5,639 m (18,500 ft) (O'Neil and Mettee 1982). Initial tests at Cold Creek indicate flow rates of 500 bbl of oil and 9062 m^3 (320,000 ft^3) of gas per day. Similar tests at South Cold Creek indicate flows of 298 bbl of oil and 6,967 m^3 (246,000 ft^3) of gas per day (Masingill 1982a).

Recent developments in coastal Alabama petroleum exploration include several discoveries of gas in southern Baldwin County in 1979, gas in lower Mobile Bay in 1979, and oil in northern Baldwin County near Blacksher in 1980.

In southern Baldwin County, Foley Field (Pensacola quadrangle) produces gas from Miocene (25 million to 10 million years before present) sand deposits in the Pensacola Clay Formation at 396- to 549-m (1,300- to 1800-ft)

depths. In addition to the five wells in Foley Field, one well nearby has resulted in the designation of West Foley Field. These initial wells indicate yields of 25,488 to 212,400 m^3 (0.9 to 7.5 million ft^3) of gas per day (Masingill 1982). It is anticipated that the poorly explored Miocene sands will produce greater yields throughout southern Baldwin County, possibly extending into Mobile Bay. Indeed, very recent finds of shallow Miocene gas have been made near Bon Secour, Weeks Bay, and Gulf Shores (Pensacola quadrangle) (O'Neil and Mettee 1982).

Mobil Oil struck gas in a deep well (6,289 to 6,365 m; 20,634 to 20,883 ft) at the mouth of Mobile Bay (Biloxi quadrangle) in October 1979. The well produced 345.3 thousand m^3 (12.2 million ft^3) of gas per day from the Norphlet Formation of Jurassic age. Mobil has received permits to continue exploratory drilling in the area (Friend et al. 1981, O'Neil and Mettee 1982).

Partly due to Mobil's find, a record $449,178,059 in cash bonuses, minimum royalties of 25%, and $5-per-acre yearly rental fees will be paid by the highest bidders for 5-year leases on 13 tracts of Alabama's State-owned offshore land. Cash offers on another 22 of the tracts were rejected by the State in the hope that the value of the tracts would increase sharply with future discoveries. The 13 tracts leased comprise 55,045 acres of the State's 147,140 acres of undrilled submerged land (Hagopian 1981).

Although there has been little development of oilfield services (platform fabrication yards, staging and supply areas) in Mobile and Baldwin Counties, this situation could easily change in the next few years. The production of petroleum from offshore drilling will require onshore infrastructure in relation to the quantity of resources found. One exception to the general absence of petroleum infrastructure in coastal Alabama is the shipyard industry, which manufactures and maintains seismic boats, crew boats, and other vessels for the oil and gas industry.

Bayou La Batre (Biloxi quadrangle) is one of the more important shipyard areas in the country, and probably the largest on the entire Gulf Coast. One shipyard (Quality Marine) is the largest manufacturer of steel fishing boats in the world. Although one shipyard builds wooden fishing boats exclusively, 13 other shipyards in the Bayou occasionally build or repair petroleum-related vessels (S. Bosarge, Bayou Area Chamber of Commerce, Bayou La Batre, AL, 20 July 1982; pers. comm.) Mobile is the only other area in Mobile and Baldwin Counties where shipyards are located. There are eight shipyards in the Mobile vicinity, all located in the industrial areas along the Mobile River, Three Mile Creek, and Chickasaw Creek (Mobile quadrangle).

Table 20 lists the companies storing, refining, and transporting (via pipeline) oil in coastal Alabama. The Miller Purchasing facility is in northern Mobile County, south of Mt. Vernon (Citronelle quadrangle), and the Marion Oil facility is located in Theodore (Mobile quadrangle). All of the other oil storage and refinery facilities are in the Mobile area along the waterfront.

The companies and facilities involved in the processing and treatment, liquid extraction, and transportation of natural gas in the study area are

Table 20. Oil facilities in coastal Alabama (Alabama Coastal Area Board and U.S. Dept. of Commerce 1979).

Storage facilities

Company	Number of Tanks	Primary capacity (bbl)
Miller-Purchasing	2	135,000
Citronelle-Mobile Gathering System	4	525,000
Amerada Hess	16	1,500,000
Marion Oil	18	770,000
Louisiana Land and Exploration	31	785,000
Mobile Bay	6	205,000
Gulf Oil	10	176,647
Radcliff-Mid Stream Fuel	2	8,000
Triangle Refinery	13	230,000
Murphy Oil	7	153,000
Shell Oil	4	102,000
Triangle Refinery of Choctaw	10	120,000
Texaco	21	414,000
Mobile Bulk Terminal	6	630,000
American Oil	6	135,000
Belcher of Alabama	7	227,500
Totals	163	6,116,147

Refineries

Company	Design capacity (BPD)[a]	Production (BPD)[a]
Marion Oil	20,000	20,000
Louisiana Land and Exploration	40,000	34,200
Mobile Bay	20,000	10,000
Chevron (asphalt)[b]	12,000	NA
Totals	92,000	64,200

Oil Pipelines

Company	Length (m)	Average daily throughput (bbl)
Hess Pipeline	56	97,425
Exxon Pipeline	36	130,000
Marion Oil	26	20,000
Citronelle-Mobile Gathering System	34	16,500
Miller Purchasing	20	2,500
Totals	172	266,425

[a] Barrels Per Day.
[b] Design capacity less than 15,000 BPD.

shown in Table 21. The gas pipelines on the maps and in the table are large, high-pressure lines, not lower pressure feeder lines found in residential areas or in natural gas fields.

Table 21. Natural gas facilities (Alabama Coastal Area Board and U.S. Dept. of Commerce 1979).

Processing and treatment (design plant capacity)			
Field	Inlet (mcfd)[a] Full well-stream gas	Gas (mcfd)[a]	Production natural gas liquids (bpd)[b]
Chunchula	10.0	14.0	4,580
Hatter's Pond	50.3	30.0	14,846
Totals	60.3	44.0	19,426

Extraction (design plant capacity)		
Field	Inlet (mcf) full-well stream gas	Production natural gas liquids
Hatter's Pond[c]	3	2,948

Gas Pipeline system		
Company	Length (mi)	Average daily distribution (mcfd)[a]
United Gas Pipeline	253	
Utility Sales:		
Mobile Gas Service	1,390	36.6
Town of Citronelle Util.	315	3.2
City of Fairhope	75	.8
Riviera Utilities	155	.7
Clark-Mobile Cos. Gas Dis.	18	6.0
City of Bay Minette	63	2.3
Industry Sales:		28.7
Florida Gas Transmission	49	No sales outlets or pickups
Delvan	50	6.4
Phillips Petroleum	16	8.8
Union Oil of California	9	-
Getty	6	-
American Oil Company	32	-
Totals	2,431	93.5

a Million Cubic Feet Per Day.
b Barrels Per Day.
c Additional capacity to be completed in June 1978.

Oil and gas production statistics for each field in Mobile and Baldwin Counties, as well as the geologic horizon from which each field produces, are given in Table 22.

Table 23 compares the relative amounts of oil, gas, and gas condensate produced in the eight counties of southwest Alabama.

Over the past decade there has been a great increase in gas production in southwest Alabama (Figure 10). Gas condensate has increased in direct proportion to the amount of gas produced, while oil production has remained constant.

Table 22. Oil, condensate, and gas production by field and pool in Baldwin and Mobile Counties (Masingill 1982b).

Field and (pool)[a]	Yearly oil (bbl)	Cumulative oil (bbl)	Yearly condensate (bbl)	Cumulative condensate (bbl)	Yearly gas (mcf)	Cumulative gas (mcf)
			Baldwin County			
South Carlton (D)[b]	236,893	4,885,750	0	0	0	0
Blacksher (G)	158,849	162,517	0	0	193,234	199,425
Little River (G)	48,584	48,584	0	0	57,037	57,037
Tensaw Lake (E)	0	164,786	0	0	0	0
Unnamed (A) S7, T9S, R4E	0	0	0	0	0	1,008
Total	207,433	375,887	0	0	250,271	257,470
			Mobile County			
Chunchula (G)	0	0	4,976,314	15,849,327	12,744,369	36,971,123
Citronelle (E)	2,088,738	133,953,580	0	0	177,984	12,106,143
Cold Creek (G)	85,799	208,934	0	0	85,048	203,697
Hatter's Pond (G&H)	0	0	2,219,674	10,710,808	9,108,452	41,375,423
South Cold Creek (G)	4,074	16,642	0	0	4,533	19,525
Total	2,178,611	134,179,156	7,195,988	26,560,135	22,120,386	90,675,911

[a] Pool or zone: (A)-Miocene (E)-Lower Cretaceous
(B)-Selma (F)-Cotton Valley
(C)-Eutaw (G)-Smackover
(D)-Tuscaloosa (H)-Norphlet

[b] Clarke & Baldwin Counties (not included in Baldwin County totals).

Table 23. Oil, condensate, and gas production in southwest Alabama, 1981 (Masingill 1982b).

County	Yearly oil (bbl)	Cumulative oil (bbl)	Yearly condensate (bbl)	Cumulative condensate (bbl)	Yearly gas (mcf)	Cumulative gas (mcf)
Baldwin	207,433	375,887	0	0	250,271	257,470
Choctaw	3,288,380	47,541,209	0	165	1,651,791	17,164,427
Clarke	485,151	5,368,908	0	0	24,682	59,869
Conecuh	9,374	254,593	0	0	4,588	319,321
Escambia	2,283,382	38,741,160	3,633,989	24,380,027	53,143,492	360,481,431
Mobile	2,178,611	134,179,156	7,195,988	26,560,135	22,120,386	90,675,911
Monroe	157,739	1,107,141	0	0	293,738	2,455,809
Washington	0	95,230	881,533	8,130,563	6,422,897	41,623,512
Total	8,610,070	227,663,284	11,711,510	59,070,890	83,911,845	513,037,750

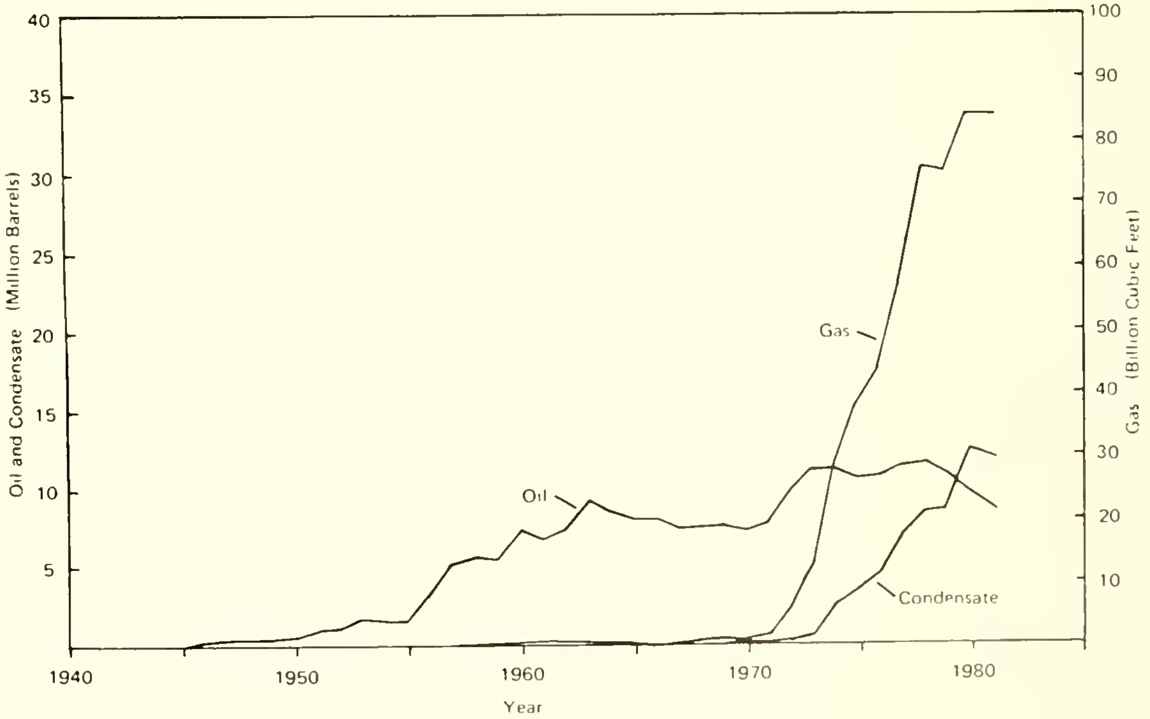

Figure 10. Oil, condensate, and gas production in Southwest Alabama, 1944-80 (Masingill 1982b).

CLAY

Clay is a ubiquitous mineral resource that is found in virtually all geologic horizons in varying concentrations and qualities. Clay is found either where it is formed, adjacent to the weathered parent material (where it is termed "residual"), or where it has been deposited by water (where it is termed "sedimentary"). Residual clays may occur either as a uniform mantle overlying the parent rock, or may accumulate into veins or dikes alongside the parent rock.

> "Clays occupying veins or dikes are usually kaolin, or a decomposition product of granite or feldspar, and commonly show definite lines of demarkation" (Jones 1926).

When sedimentary clays are deposited by water, they may be interspersed with any other type of sedimentary deposit, such as coal or limestone. Clays deposited as sediments may extend uniformly over large areas or may be quite small lenses. Sedimentary clay particles are generally finer than those in residual clay. When subjected to great pressures, the clay particles may consolidate to form shales. If shales are ground finely, they regain the characteristic plasticity of clays (Jones 1926).

There are four types of clays mined in Alabama: bentonite, kaolin, fire clay, and common clay. Bentonite is a decomposition product of volcanic ash. Bentonite is used as a binder in foundry sand or as drilling mud, and is mined primarily in Lowndes County (Smith and Gilbert 1975).

Kaolin is used for the manufacture of refractory (heat-resistant) products. It is mined in Henry, Marion, and Barbour Counties, where it is usually found in association with bauxite (aluminum ore) (Smith and Gilbert 1975).

Fire clay is also used for refractory purposes, in making heat-resistant bricks and ceramics. Fire clay is primarily mined in Calhoun, Blount, and Walker Counties, where it is often found underneath coal strata, and is subsequently mined in conjunction with coal operations (Smith and Gilbert 1975).

Common clay accounts for over 80 percent of the clay mined in Alabama and is used for building brick and lightweight aggregate (Corey 1976). Clays occurring within Mobile and Baldwin Counties are found in small lenses within the Miocene and Plio-Pleistocene (Citronelle Formation) deposits. The only large area of exposed clay and the only clay mining operation within the two coastal counties occurs near Clay City (Pensacola quadrangle) in southern Baldwin County. At this site, the Fish River has exposed the Miocene/Pliocene/Pleistocene strata. This clay is mined in shallow open pits and is used for brick, tile, and sewer pipe (Moser and Chermock 1978).

The Citronelle Formation (mid-Pliocene to early Pleistocene) and the high terrace deposits (Pleistocene) are difficult to differentiate as they are both composed of sand, clay, and some gravel (Moser and Chermock 1978, Isphording and Lamb 1971). Clay reserves in the Citronelle Formation are

lenticular, and may be up to 3 m (10 ft) thick, but extend laterally only a few hundred feet. These deposits usually grade laterally into sand or clayey sand. The upper surfaces of the deposits may be eroded, resulting in irregular, discontinuous beds. These kaolinitic deposits are less plastic than other clays and are used to control shrinkage in bricks and ceramics. Older deposits of clay, of Miocene age, are found in northern Mobile and Baldwin Counties, as well as along the major streams in Mobile County. Much of the clay is difficult to locate, as it is concealed beneath a thick soil layer and vegetation (Moser and Chermock 1978).

The quantity of sand, gravel, and clay mined in Mobile and Baldwin Counties has increased over the past decade, although production figures vary considerably from year to year. Production of these minerals in the study area increased sevenfold between 1971 and 1979, from 208,610 metric tons (230,000 short tons) to 1,541,900 metric tons (1,700,000 short tons). This comprises about 14% of the total production from the State of Alabama (Friend et al. 1981).

The 1973 Minerals Yearbook (Corey 1976) quotes production of 1,474,000 metric tons (1,624,000 short tons) of clay in Alabama in 1972, which increased 17% to 2,630,000 metric tons (2,900,000 short tons) in 1973. The 1973 Atlas of Alabama (Lineback 1973) states the value of the annual production of clay statewide is $7,000,000, which corresponds well with Smith and Gilbert's (1975) figure of $8,000,000 in 1975. Table 24 summarizes the production of clays in coastal Alabama for 1977 and 1979.

Smith and Gilbert (1975) list the annual production of fire clay statewide at 363,000 metric tons (400,000 short tons) and that of common clay and kaolin at over 1,816,000 metric tons (2,000,000 short tons), although Beg (1980) lists the statewide annual production of clays other than bentonite ("other clays" and "kaolin") at only 1,541,300 metric tons (1,697,841 short tons). Table 25 summarizes the production of clays, excluding bentonite, in Alabama for 1975, 1977, and 1979.

Beg (1980) lists production of 103,500 metric tons (114,000 short tons) of bentonite statewide, whereas Smith and Gilbert (1975) quote 163,400 metric tons (180,000 short tons) in Lowndes County alone. It is not clear whether these data reflect a real decrease in clay production from 1975 to 1980 or merely a difference in method of data collection. Table 26 shows the relative importance of Alabama clay reserves to the nation as a whole.

SAND AND GRAVEL

Sand grains are formed by weathering action upon parent rocks, particularly siliceous or other hard rocks, such as mica, magnetite, or cassiterite. Most sand particles are quartz. The particles are rounded by abrasion and sorted by the actions of wind and water. In water the larger, heavier particles settle out first, with the smaller, lighter particles remaining in suspension longer and being distributed over wider areas. These suspended particles are carried downstream, where they may settle along sand bars. The average depositional grain size is a function of the local current regime. Eventually the sand may be covered by other sediments, or it may be trans-

Table 24. Production (net tons) of sand and clay in the Alabama Coastal Region 1977[a] and 1979[a] (Alabama Department of Industrial Relations, Division of Safety and Inspection 1977, 1979).

Type mineral	1977	1979
Mobile County		
clay	--	8,000
sand and clay	380,598	1,488,758
Baldwin County		
clay	11,595	25,555
sand and clay	92,926	84,400
Totals for both counties		
clay	11,595	33,555
sand and clay	473,524	1,573,158

[a]For fiscal year ending September 30.

Table 25. Quantity and value of clay production[a] in Alabama, 1975, 1977, 1978, 1979 (U.S. Department of the Interior, Bureau of Mines 1976, 1979a and 1979b).

	Clays (excluding bentonite)	
Year	Quantity (1000 short tons)	Value ($1000)
1975	2,231	9,077
1977	2,677	21,984
1978	2,755	25,371
1979	2,571	33,824

[a]Production is measured by mine shipments, sales, or marketable production (including consumption by producer).

Table 26. Alabama's role in U.S. clay production in 1978[a] (U.S. Department of the Interior, Bureau of Mines 1979b).

Major commodity	Share of U.S. output (%)	Rank in Nation	Reserves
Clays:			
Bentonite	W[b]	4	Small
Common	5	7	Large
Fire	13	4	Moderate
Kaolin	5	3	Small

[a] Preliminary figures.
[b] W = Withheld to avoid disclosing individual company confidential data.

ported to the sea, where the process of rounding, sorting, and deposition continues. If covered by thick sediments and consolidated by pressure, sand may eventually form sandstone. Sandstone varies in texture from very coarse-grained, when it is an aggregation of large particles, to sandy shale, when it is intermixed with the much smaller silt particles (Jones 1926).

Gravel originates in the same manner as sand, by the weathering of parent rocks. The larger gravel particles are likewise abraded, rounded, and sorted as they are transported downstream. Gravel may then be deposited on bars by itself or with sand along streams, or less likely, transported out to sea. Deposits of sand and gravel are usually intermixed, which necessitates washing to screen out the particle sizes desired for commercial purposes (Jones 1926).

Deposits of sand and gravel within the Mobile-Baldwin County study area are Miocene [25,000,000 to 10,000,000 years before present (ybp)], Pliocene (10,000,000 to 600,000 ybp), Pleistocene (600,000 to 12,000 ybp), or Recent (12,000 ybp to present) in age. Sand and clay deposits of Miocene age are found in the northern half of the study area and include Catahoula sandstone and Paynes Hammock sand. Mid-Pliocene and early Pleistocene deposits comprise the Citronelle Formation, which includes layers of sand, clay, and gravel. The terrace and alluvial deposits surrounding the major streams in the area are primarily late Pleistocene and Holocene in age. During the Holocene, silty and clayey sands were also deposited along the gulf coast (Moser and Chermock 1978).

Table 27, from Moser and Chermock (1978), shows the generalized strata significant to coastal Alabama's mineral resources. A comprehensive

Table 27. Geologic strata containing commercial sand, clay, and gravel in coastal Alabama.

System	Series	Unit	Material
Quaternary	Holocene	Alluvium, terrace, beach, and deltaic deposits	Silty and clayey sand and gravel.
	Late Pleistocene	Terrace deposits	
	Early Pleistocene	Citronelle Formation	Sand, gravel and clay.
Tertiary	Pliocene	Citronelle Formation	Sand, gravel, and clay.
	Miocene	Catahoula sandstone and Paynes Hammock sand, undifferentiated	Sand and clay.

discussion of the subsurface stratigraphy of the Alabama coastal area is found in O'Neil and Mettee (1982). Additional detailed information is found in Reed (1971a, 1971b), Isphording and Lamb (1971), and Isphording (1976).

Sand and gravel from both the Citronelle Formation and the more recent terrace deposits are used for construction aggregates, foundry sand, and other applications. Many of the terrace and alluvial deposits are too poorly sorted (i.e., contain too much clay and silt) to be of commercial use, although they are sometimes used in road construction and maintenance. High-quality, fine- to medium-grained quartz sand deposits are located along several creeks and adjacent to the Mobile River. In some areas the sand contains shell, which limits its uses (Moser and Chermock 1978). In the nearshore waters off Dauphin Island (Biloxi quadrangle) lie reserves of heavy mineral sands which are not currently being exploited (Alabama Coastal Area Board and U.S. Dept. of Commerce 1979).

The use for which the sand or gravel is intended determines which properties are desirable. The following general guide to specifications is given in Moser and Chermock (1978):

> "Sand used as aggregate in asphalt, concrete, mortar, and plaster should be clean, siliceous, angular, and free from salts and organic matter.
>
> "Gravel used as coarse aggregate in concrete, as base coarse in roads, as fill material, and as ballast should consist of material that is tough, durable, and chemically stable. Quartz gravel is preferred for use in concrete aggregate.

Sand and gravel having a silica content of more than 95 percent may be used for glass sand, foundry sand, engine sand, abrasive sand, filter sand, and flux in the smelting of metal ores and in the manufacturing of silicones."

Table 28 from Corey (1976) provides the various quantities and dollar values of sand and gravel used for specific purposes in Alabama in 1972 and 1973.

Virtually all sand and gravel in coastal Alabama is mined from open pits, and whenever the deposits are overlain by shallow water, a dredge is used for

Table 28. Alabama: sand and gravel sold or used by producers, by class of operation and use (thousand short tons and thousand dollars).

Class of operation and use	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Commercial operations:				
Sand:				
Building	1,796	1,937	2,491	2,832
Fill	98	94	140	102
Fire or furnace	--	--	4	16
Paving	814	1,299	1,452	2,274
Other uses[a]	625	1,028	502	984
Total[b]	3,334	4,358	4,590	6,207
Gravel:				
Building	992	1,727	1,577	2,427
Fill	W[c]	W	249	149
Paving	1,796	2,220	2,918	4,578
Miscellaneous	W	147	138	130
Other uses[d]	230	78	327	368
Total[b]	3,018	4,171	5,208	7,652
Government-and-contractor operations:				
Sand: Paving	--	--	3	4
Gravel: Paving	--	--	4	6
Total sand and gravel[b]	6,352	8,530	9,805	13,870

[a] Includes blast (1973), engine, molding, chemicals (1972), railroad ballast, and other industrial sands.
[b] Data may not add to totals shown because of independent rounding.
[c] W = Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[d] Includes railroad ballast (1973) and other gravel.

excavation (Smith and Gilbert 1975). Although mining of sand and gravel is sometimes done by drag lines and front-end loaders, most excavation in the study area is by hydraulic dredge. Nearly all of the sand and gravel is processed by washing (Simpson and Smith 1968).

Based on a maximum thickness of 3 m (10 ft) for the Citronelle Formation and terrace deposits, and a minimum of 1.3 m (4 ft) for the alluvial deposits, it has been estimated by Szabo et al. (1969) and Szabo and Clarke (1969) that Mobile County contains over 218 million metric tons (240 million short tons) of commercially available sand, while an additional 9.1 billion metric tons (10 billion short tons) lie in Baldwin County.

Beg (1980) gives a figure for total sand and gravel production in Alabama of 8,219,180 metric tons (9,053,955 short tons) per year. The Atlas of Alabama (Lineback 1973) states that the value of sand and gravel production statewide was $9 million as of 1973. Figure 11 shows the variability in the quantities of sand, gravel, and clay produced in Baldwin and Mobile Counties from 1969 to 1975. Statewide production quantities and values for sand and gravel from 1975 to 1979 are given in Table 29. Production quantities and values from sand and gravel, sand and clay, and sand in Mobile and Baldwin Counties in 1977 and 1979 are in Table 30.

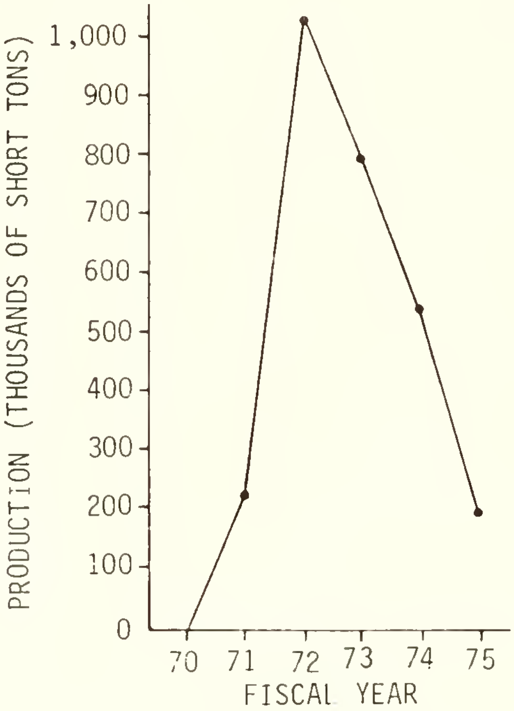

Figure 11. Sand, gravel, and clay production in Baldwin and Mobile Counties, 1969-75 (for October 1-September 30 fiscal year)(Moser and Chermock 1978).

Table 29. Quantity and value of sand and gravel production[a] in Alabama (U.S. Department of the Interior, Bureau of Mines 1976, 1979a, and 1979b).

Year	Sand and gravel (1000 short tons) Quantity (1000 short tons)	Value ($1000)
1975	9,232	17,376
1977	14,372	35,204
1978	14,500	37,000
1979	13,747	31,319

[a] Production measured by mine shipments, sales, or marketable production (including consumption by producers).

Table 30. Production (net tons) of sand, gravel, and clay in the Alabama coastal region, 1977[a], 1979[a] (Alabama Department of Industrial Relations, Division of Safety and Inspection 1977, 1979).

Type mineral	1977[a]	1979[a]
Mobile County		
Sand	70,400	59,085
Sand and clay	380,598	1,488,758
Sand and gravel	--	--
Baldwin County		
Sand	391,288	--
Sand and clay	92,926	84,400
Sand and gravel	36,773	20,000
Totals for both counties		
Sand	461,688	59,085
Sand and clay	473,524	1,573,158
Sand and gravel	36,773	20,000

[a] For fiscal year ending September 30.

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SOURCES OF MAPPED INFORMATION

OIL AND GAS

Petroleum and Natural Gas Fields and Wells

Geological Survey of Alabama. 1982. Unpublished maps of counties and fields. State Oil and Gas Board. University.

These large-scale (1 inch equals 1 mi) maps include the exact locations of active oil and gas wells, abandoned wells, dry holes, and injection wells. Additional maps of individual fields delineate the boundaries of fields, as designated by the Oil and Gas Board. These maps are updated weekly.

Storage, Processing and Treatment, and Refining Facilities and Pipelines

Alabama Coastal Area Board and U.S. Dept. of Commerce. 1979. The Alabama coastal area management program (hearing draft). Alabama Coastal Area Board, Daphne. 116 pp.

Contains a small-scale (approximately 1:500,000) map of the locations of the refineries, processing and treatment plants, and storage facilities. Accompanying the maps are tables giving production statistics for the various plants and storage facilities. Also mapped are the general locations of oil and gas pipelines in the area, their size, and operator.

Masingill, J. H. ed. 1982a. The petroleum industry in Alabama, 1980. Geol. Surv. Ala. Oil Gas Rep. 3D, 46 pp.

Contains a small-scale (approximately 1:1,400,000) map of the pipelines in southwestern Alabama and indicates their operators. Includes the locations of refineries and gas processing plants.

U.S. Department of the Interior Geological Survey. 7.5-minute-quadrangle maps. U.S. Geological Survey, Reston, VA.

These detailed, colored 1:24,000-scale maps contain the locations of pipelines, storage facilities, and plants, (many are out-of-date and do not show recent construction).

Shipyards

U.S. Army Corps of Engineers, Mobile District. 1982. Survey services, including hydrographic and/or topographic services within the civil boundaries of the Mobile District. U.S. Army Corp of Engineers, Mobile. 82 pp.

A book of very detailed engineering maps at a scale of 1 inch equals approximately 60 ft. Contains the locations of larger shipyards and dry-dock ramps in the district area, including Mobile and Bayou La Batre.

CLAY, SAND, AND GRAVEL

Mineral Deposits

Geological Survey of Alabama. 1977. Mineral resources of southwest Alabama. Geol. Surv. Ala. Map 180.

A colored 1:250,000-scale map showing locations of mineral deposits, including generalized petroleum fields.

Szabo, M. W. and O. M. Clarke, Jr. 1969. Mineral resources map of Baldwin County, Alabama. Geol. Surv. Ala. Spec. Map 83.

A detailed colored map showing the locations of minerals at a scale of 1 inch equals 2 mi (1:126,720). Opposite side contains a brief narrative about mineral resources in the county.

Szabo, M. W., O. M. Clarke, Jr., and D. B. Moore. 1969. Mineral resources map of Mobile County, Alabama. Geol. Surv. Ala. Spec. Map 89.

A detailed colored map showing the location of minerals at a scale of 1 inch equals 2 mi (1:126,720). Opposite side contains a brief narrative about mineral resources in the county.

Active Mining Sites:

Beg, M. A. 1980. Directory of active mines and quarries in Alabama. Geol. Surv. Ala. Map 176.

A statewide 1:1,000,000 scale map, with colored symbols showing the location of the different types of minerals mined. Reverse side of map includes a directory by mineral and county of business addresses of mines and quarries, their location by section, type of geologic formation mined, and type of mine.

CLIMATOLOGY AND HYDROLOGY

INTRODUCTION

This section relates information on water availability and its use in coastal Alabama. Included is a description of the coastal climate and how it affects the area, stream and river discharge, and surface and ground water availability and quality. Currents and their effects on salinities in the coastal estuaries are also discussed.

CLIMATE

Temperature

The climate of coastal Alabama is primarily humid subtropical, due to the warming influence of the Gulf of Mexico. This large warm-water surface is a major contributor to warm, humid summers, and mild winters, with a fairly consistent range of temperature extremes (Lineback 1973).

Coastal Alabama air temperatures are relatively mild, with an average annual temperature in Mobile of 20 °C (68 °F). Mean annual temperature variation is approximately 10 °C (18 °F) (Table 31). Summer temperatures are rarely high ranging between 21 and 32 °C (70 and 90 °F). Temperatures in winter generally range between 4 to 16 °C (40 and 60 °F), with temperatures below freezing occurring on an average of 22 days per year. Periods of freezing temperatures generally do not last more than 2 or 3 days. The lowest mean monthly temperatures, 10 °C (50 °F), occur in January, while July produces the highest average temperatures (28 °C, 82 °F). Temperature extremes in the Mobile area vary from a maximum of 40 °C (104 °F) (July 1952) to a low of -18 °C (-1 °F) (February 1899) (National Climate Center 1980).

Mobile and Baldwin Counties have a growing season ranging from 230 days in the northern sector to 300 days in areas near the coast. The first killing frost occurs in early November in the northern parts of the counties and early December in areas near the coast. The last killing frost occurs in mid-February near the coast (O'Neil and Mettee 1982).

Precipitation

The normal annual rainfall in coastal Alabama is the highest in the state and among the highest in the United States. Average annual rainfall in the Mobile area is about 162.5 cm (64 inches) (Table 32). Rainfall is fairly evenly distributed throughout the year with a slight maximum at the height of the summer thunderstorm season in July and a slight minimum during the late fall in October.

Table 31. Air temperatures in coastal Alabama based on 25 years data, 1955-79 (modified from Crance 1971).

Location	Mobile[a] (Mobile quad)	Bay Minette (Bay Minette quad)	Fairhope (Bay Minette quad)	Robertsdale (Bay Minette quad)	Fort Morgan[b] (Pensacola quad)
	Mean temperature (° F)				
January	51.7	49.8	50.8	49.6	52.6
February	54.3	53.2	53.9	52.6	54.9
March	60.2	59.8	60.2	59.5	54.2
April	67.2	67.9	67.8	67.2	68.5
May	74.3	74.1	74.2	72.4	76.1
June	80.3	79.1	79.2	78.8	81.0
July	81.8	80.8	81.2	81.2	82.5
August	81.6	82.2	80.4	79.5	82.5
September	78.1	77.1	77.6	76.9	79.4
October	68.8	71.1	68.4	67.7	71.3
November	58.9	59.0	59.6	59.0	62.2
December	53.0	50.8	52.7	52.5	55.5
Variation	30.1	32.4	30.4	31.6	29.9
Annual[c]	67.5	66.8	67.4	66.56	68.9

[a] 1941-80.
[b] Station closed 1975.
[c] Mean annual temperature and monthly means may not correspond due to method of calculation.

Of the six weather stations for which rainfall data is presented, Ft. Morgan (Biloxi quadrangle) has the lowest annual rainfall, 128 cm (50.49 inches), while Robertsdale (Bay Minette quadrangle) has the highest, 168 cm (66.29 inches).

Table 32. Rainfall in coastal Alabama based on 25 years data, 1955-79 (modified from Crance 1971).

Location	Mean precipitation (inches)					
	Mobile[a] (Mobile quad)	Bay Minette (Bay Minette quad)	Fairhope (Bay Minette quad)	Robertsdale (Bay Minette quad)	Gulf Shores[b] (Pensacola quad)	Fort Morgan[c] (Pensacola quad)
January	4.73	5.15	4.95	5.33	4.36	3.52
February	4.93	5.26	5.04	5.89	5.67	3.98
March	6.63	6.29	5.82	5.89	5.01	4.91
April	5.13	4.95	4.43	4.23	4.31	3.53
May	4.71	5.71	5.06	5.04	3.32	2.71
June	5.49	5.38	5.89	5.92	4.87	4.28
July	7.57	7.94	7.71	8.12	5.97	5.78
August	6.62	7.03	6.56	7.52	6.98	5.04
September	5.62	6.13	7.10	7.41	8.61	8.30
October	3.20	3.12	3.41	3.63	3.70	3.46
November	3.73	3.24	3.68	3.90	3.11	2.90
December	5.15	5.12	4.70	5.97	4.02	4.10
Annual[d]	63.56	62.70	64.74	66.29	59.60	50.49

[a] 1941-80.
[b] 1955-74 station closed.
[c] 1955-75 station closed.
[d] Annual mean may not correspond to monthly means due to method of calculation.

During the spring and summer, south and southeasterly winds blow from the Gulf of Mexico. These warm offshore winds are heavily laden with moisture and the resulting convective activity generates numerous thunderstorms. This thundershower activity, which averages about 87 days a year, generates the maximum rainfall of the year (O'Neil and Mettee 1982).

At Robertsdale the average monthly precipitation in July is 20.6 cm (8.12 inches); at Mobile, 19.2 cm (7.57 inches). At Ft. Morgan (Biloxi quad-

rangle) and Gulf Shores (Pensacola quadrangle) the highest amounts of monthly rainfall occur in September (Table 32), with respective amounts of 21.1 cm (8.30 inches) and 21.9 cm (8.61 inches).

Rainfall in October averages the lowest for the year in coastal Alabama, ranging from 9.4 cm (3.70 inches) at Gulf Shores to 7.9 cm (3.12 inches) at Bay Minette (Bay Minette quadrangle). The lowest monthly average rainfall in coastal Alabama occurs at Ft. Morgan during November.

During winter months frontal systems and on-shore horizontal convergence produce much of the precipitation in coastal Alabama. Snow (which averages 0.2 inches/yr), hail, and sleet are rare. Most of the rainfall occurs in showers and long periods of heavy rainfall are rare. Monthly rainfall during December, January, and February averages about 74 cm (29 inches)/month.

Cloud Cover, Fog, and Relative Humidity

Cloud cover in the vicinity of Mobile has an annual value of about 6/10 (60 percent of total sky area covered in daylight periods). In general, cloud cover tends to be highest in winter and summer and lowest in spring and fall. October has the minimum mean cloud cover with just over 4/10, while January and July have maximum means of almost 7/10. Summer cloudiness is mainly convective cumulus or high thin clouds, while winter cloudiness is the result of frontal systems associated with extratropical cyclones and may produce gray, overcast days (O'Neil and Mettee 1982).

Fog is the main visibility inhibitor in coastal Alabama, occurring from November through May. Winter fogs are fairly frequent and generally produce the lowest visibilities of the year, 0.4 km (0.25 mi) (O'Neil and Mettee 1982).

Because of the availability of water vapor from the Gulf surface, high humidities prevail throughout the year with little seasonal variation. Annual mean relative humidity at Mobile varies from 56% to 87% according to the time of day, with highest readings at 6 a.m. E.S.T. Annual average humidity is approximately 74% (National Climate Center 1980).

Winds

The prevailing surface winds for the coastal Alabama area are southerly for March through July, easterly for August and September, and northerly for the remaining months. The average annual wind velocity in coastal Alabama is 13.3 kmph (8.3 mph) (Chermock 1974). The Bermuda High is the most permanent feature affecting the general circulation. During the spring, this subtropical anticyclone intensifies and extends its western boundaries over the Gulf region. This produces periods of prolonged light winds from a south to southeasterly direction. The greatest (attained) winds occur from May through November with passing hurricanes. The highest recorded wind speed in the study area was 233 kmph (145 mph) on Dauphin Island during Hurricane Fredric in September 1979 (Corps of Engineers 1981). The Bermuda High begins to weaken in autumn and move slightly southeastward. This, along with the southern movement of the equatorial trough, permits the continental pressure

systems to extend into the gulf area setting up the prevailing northerlies, which on the average are the highest winds, from November through February (Corps of Engineers 1973).

Annual wind roses for three stations in coastal Alabama for which data is available are shown on the atlas maps; Mobile, Batesfield (Mobile quadrangle), Dauphin Island (Biloxi quadrangle) and Foley, Alabama (Pensacola quadrangle). The wind roses show the percentage of the time the wind blows at each velocity and direction.

Extratropical Cyclones

Some 15 to 20 significant frontal systems, or winter storms and their associated polar air masses penetrate the Gulf of Mexico each year, bringing cool air and strong northerly winds. From October to March these systems produce rapid temperature drops and the highest frequency of winds above 33 kn. The extratropical cyclones (low pressure systems with counterclockwise winds) are usually followed by associated migratory anticyclones (high pressure systems with clockwise winds). Continental systems continue to affect the gulf until the Bermuda High strengthens its influence in the early spring (U.S. Army Corps of Engineers 1973).

Tropical Cyclones and Hurricanes

The majority of tropical cyclones (low pressure systems with counterclockwise winds originating in tropical regions) affecting Alabama originate as cyclonic disturbances from the Abyssinian Plateau of eastern Africa. These circular winds move westward across the southern Sahara desert and begin to pick up energy and moisture as they move across the eastern Atlantic Ocean. It is not until these storms gather size, strength, and a characteristic cloud pattern that they can be observed and monitored via satellite (National Science Board 1972).

About 100 of these cyclonic disturbances form every year, but 75% dissipate and never develop low-pressure centers with well-defined circulating wind curents. About 10 per year develop sufficient strength (wind velocities of 63 to 117 kmph [39 to 73 mph]) to be classified as tropical storms. Approximately six of these tropical storms will strengthen into hurricanes (wind velocities greater than 119 kmph (74 mph), and an average of two of these per year will impact the coast of the United States (Chermock 1976).

Not all Atlantic hurricanes originate near the coast of Africa. A few each year originate as a result of cold fronts degenerating and encountering warm moist tropical conditions. Most of these hurricanes develop between 10° and 20° longitude in an area called the doldrums, and none have developed within 9° of the equator. The paths of hurricanes that have influenced Alabama since 1887 are shown in Figure 12. Hurricanes impact Alabama from June to October, most commonly in September (Figure 13). Hurricanes impacting the gulf coast early in the season (June or July) generally originate in the western Atlantic or western Caribbean and are usually weak. Hurricanes later in the season (August and September) generally develop into recognizable storms in the eastern Atlantic near the Cape Verde Islands.

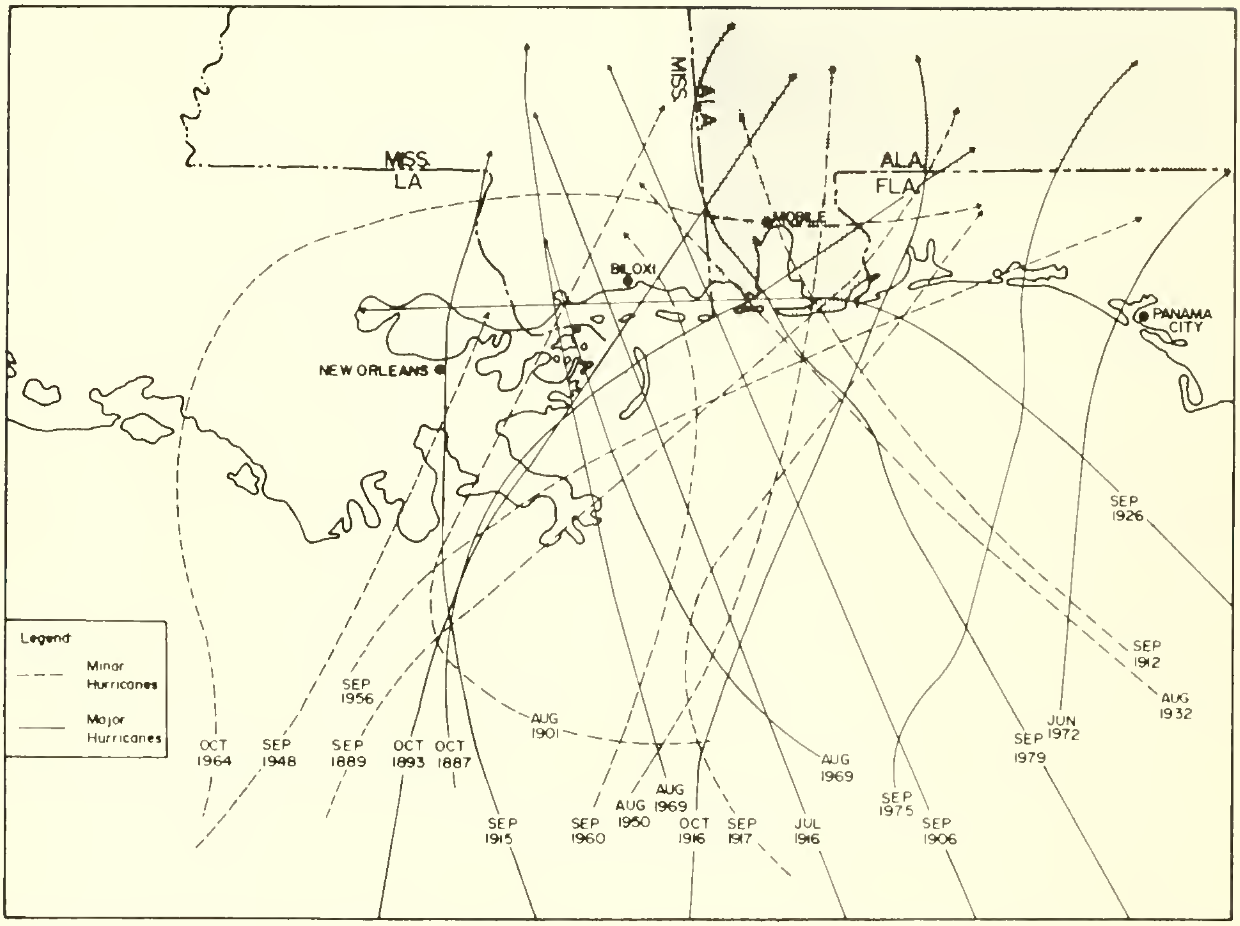

Figure 12. Paths of hurricanes affecting Alabama (modified from U.S. Army Corps of Engineers 1967).

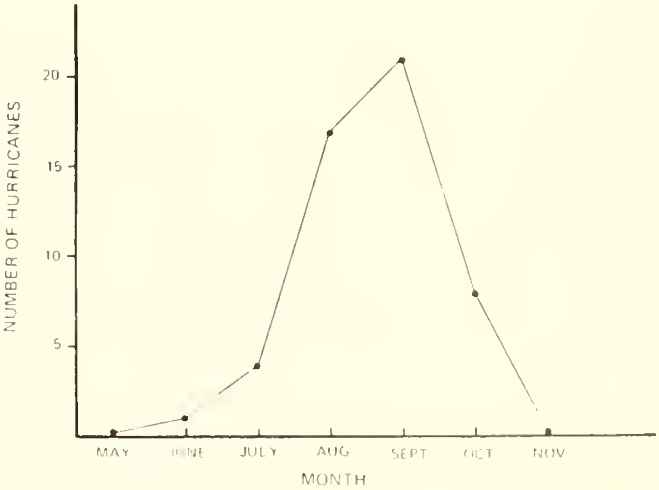

Figure 13. Monthly frequency of hurricanes affecting Alabama since 1711 (O'Neil and Mattee 1982; modified from Chermock 1974).

These storms have the potential to gather strength as they travel all the way across the Atlantic and as a result are usually more powerful than the earlier storms (U.S. Army Corps of Engineers 1967).

The coast from Mobile Bay to Cape San Blas, Florida have the highest probability of damage from tropical storms along the Gulf Coast (Figure 14). This area has sustained damage from tropical storms in excess of 20 times between 1901 and 1979.

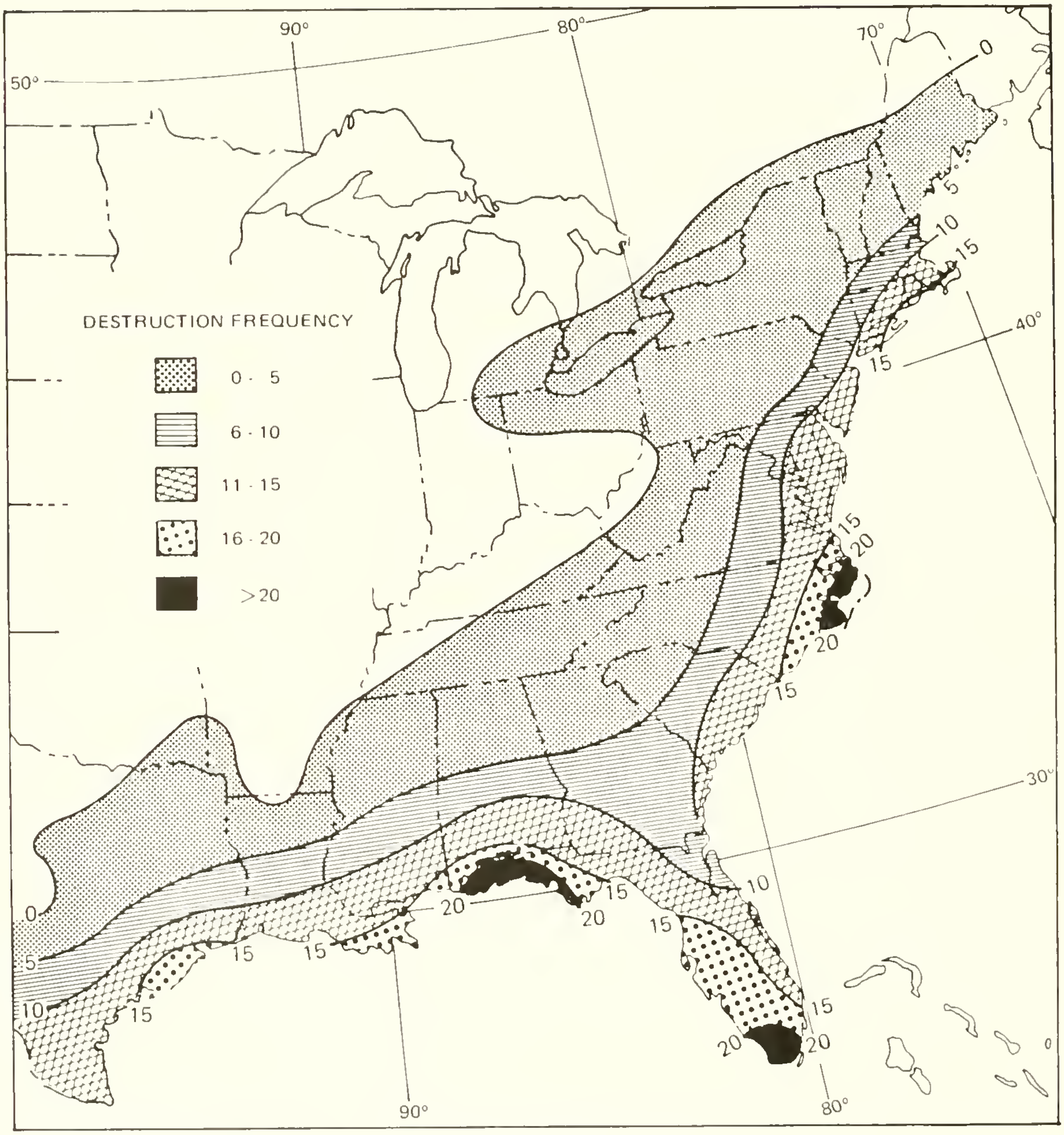

Figure 14. Frequency of destruction by tropical storms, 1904-77 (Long 1978).

Simpson and Lawrence (1971) estimated the probability of tropical storms, hurricanes, and major hurricanes for the 80 km (50 mi) coastline between Biloxi, Mississippi, and Mobile, Alabama. They predict an annual probability of 13% for a tropical storm, 6% for a hurricane, and 1% for a major hurricane striking the area.

The U.S. Army Corps of Engineers, on the basis of previous records, have predicted the probable recurrence interval for storm tides in coastal Alabama (Table 33). At Dauphin Island, for example, an 11.5-ft tide would be expected once every 100 years. These tides could occur in any year of the time period or not occur at all. The predicted maximum height could also be exceeded, as during Hurricanes Camille and Fredric (Chermock 1976).

Winds within hurricanes, like tornadoes, travel counterclockwise in the northern hemisphere. Winds are most intense near the center (eye) of the storm, although the eye itself is fairly calm. As the hurricane moves forward, winds are highest on the right side and weakest on the left. The

Table 33. Probable recurrence interval for storm tides in coastal Alabama (Chermock 1976).

	Elevation above mean water level (ft)				
Location	1 Year	10 Years	20 Years	50 Years	100 Years
Coastal Area-Fort Morgan to Gulf Shores (Pensacola quad)	3.6	7.0	8.3	10.2	11.4
Bayou St. John Area (Pensacola quad)	3.0	5.0	6.2	7.2	8.5
Perdido and Wolf Bay Area (Pensacola quad)	2.6	3.9	4.7	5.7	6.5
Grand Bay and Bayou La Batre (Biloxi quad)	3.6	6.8	8.8	11.4	13.2
Dauphin Island (Biloxi quad)	3.6	5.8	7.6	9.8	11.5
Mobile Bay (Mobile quad)	3.6	5.8	7.5	9.4	10.6

average forward speed of hurricanes is about 19 kmph (12 mph), but may approach 64 kmph (40 mph) in the temperate regions (Chermock 1974). Because of the counterclockwise movement within the storm, a forward speed of, for example, 30 kmph (19 mph) will result in the winds on the right side of the hurricane traveling 60 kmph (38 mph) faster than the winds on the left side relative to the surface of the earth. Winds within a hurricane are often in excess of 161 kmph (100 mph) and may even exceed 322 kmph (200 mph), as did Hurricane Camille in 1969. Since hurricanes striking the gulf coast are generally moving northward, the highest winds are to the east of the landfall of the storm eye (Chermock 1976).

Destruction from hurricanes results from high winds, storm surge, and flooding rains. In addition, tornadoes may occur on the storm's periphery. Despite the incredible speeds associated with hurricane winds, most destruction is a result of storm surge and flooding. Wind damage is more severe in areas immediately along the coast, since wind speed diminishes rapidly inland due to friction with the land surface. The most extreme wind and barometric pressures associated with hurricanes in Alabama are shown in Table 34.

Table 34. Extreme pressure and wind data of hurricanes recorded along the Alabama coast since 1892 (modified from U.S. Army Corps of Engineers 1967).

Date hurricane crossed coast	Number of miles and direction center passed Mobile	Lowest barometric pressure (inches)	Location (quad sheet [a])	Maximum wind velocity and direction (mph)	Location (quad sheet)
Oct. 2, 1893	50W	29.16	Mobile (1)	80SE	Mobile (1)
Aug. 15, 1901	70W	29.32	Mobile (1)	61	Mobile (1)
Sept. 27, 1906	20SW	28.84	Mobile (1)	94	Ft. Morgan (2)
Sept. 20, 1909	150SW	29.62	Mobile (1)	52	Ft. Morgan (2)
Sept. 14, 1912	20W	29.37	Mobile (1)	60SE	Mobile (1)
Sept. 29, 1915	100W	29.45	Mobile (1)	60SE	Mobile (1)
July 5, 1916	20W	28.38	Ft. Morgan (2)	107E	Mobile (1)
Oct. 18, 1916	60E	29.22	Mobile (1)	128E	Mobile (1)
Sept. 28, 1917	100SE	29.17	Mobile (1)	96NNE	Mobile (1)
Sept. 20, 1926	30S	28.20	Perdido Beach (2)	94N	Mobile (1)
Sept. 1, 1932	25SSW	29.03	Bayou La Batre (3)	57E	Mobile (1)
Sept. 19, 1947	110SW	29.54	Mobile (1)	53E	Mobile (1)
Sept. 4, 1948	90W	29.55	Ft. Morgan (2)	42S	Mobile (1)
Aug. 30, 1950	20E	28.92	Ft. Morgan (2)	75	Ft. Morgan (2)
Sept. 24, 1956	80S	29.49	Mobile (1)	58	Mobile (1)
Sept. 15, 1956	80W	29.48	Mobile (1)	74	Dauphin Island (3)
Oct. 3, 1964	230W	29.39	Alabama Port (3)	80NNW	Alabama Port (3)
Aug. 17, 1969	85W	29.44	Mobile (1)	74	Mobile (1)
June 19, 1972	180SE	29.26	Dothan (4)	43NNW	Dothan (4)
Sept. 23, 1975	90SE	28.85	Ozark (4)	120	Ozark (4)
Sept. 14, 1979	25SW	27.84	Dauphin Island (3)	145	Dauphin Island (3)

[a] Quad sheet: (1) Mobile, (2) Pensacola, (3) Biloxi, (4) Not in study area.

Destruction from storm surge or rise in water level due to strong sustained winds is likewise mainly restricted to areas fronting the ocean. Water and wind-driven waves are capable of great devastation, especially when the surge raises the water level 8 m (25 ft) and waves are driven by 322-kmph (200-mph) winds, as happened during Hurricane Camille. Surge is more pronounced in areas where deep water is near shore, as in the area from Mobile to Panama City, Florida. As the surge moves inland with the storm, a shallow bottom would cause resistance and reduce the surge. The surge may also be accentuated in the study area by the funnel shape of Mobile Bay, which concentrates the surge. When a storm surge occurs during a normal astronomical high tide, its effect is even greater (Chermock 1976).

The hurricane surge during Hurricane Frederic in September 1979 is the highest ever recorded in coastal Alabama (Table 35). The surge reached a maximum of 5.2 m (17 ft) above mean sea level, about 4.8 km (3 mi) west of Perdido Bay (Pensacola quadrangle). The eastern shore of Mobile Bay (Mobile quadrangle) had high water of 2.4 to 3 m (8 to 10 ft), while the western shore (Pensacola and Bay Minette quadrangle) had a high water of 2.1 to 3.6 m (7 to 12 ft) above mean sea level. Further from the open ocean, the Mobile and Tensaw Rivers (Mobile and Bay Minette quadrangle) had a high water reading of 1.4 m(5.5 ft). Frederic inundated about 34,800 ha (87,000 acres) in Mobile and Baldwin Counties. The areal extent of inundation is shown on the atlas sheets. The shoreline along the Mississippi Sound, Dauphin Island (Biloxi quadrangle), Ft. Morgan Peninsula, the Gulf Shores area (Pensacola quadrangle) and the Lower Mobile Delta (Mobile and Bay Minette quadrangle) were all inundated to some degree by the storm surge. The entire economic loss attributable to Frederic was approximately $1.5 billion, economically one of the most costly hurricanes ever experienced in Alabama (U.S. Army Corps of Engineers 1981).

Damage inland from hurricanes is mainly a result of flooding from heavy rains. After devastating the Louisiana and Mississippi coasts, Hurricane Camille caused flash floods and landslides in West Virginia and Virginia. In areas with short stream patterns, the flooding may rapidly reach a coast already inundated by a storm surge. In cases where the rain falls far inland, the flooding may reach the coast after the storm surge recedes and recovery operations are underway or may flood distant areas not otherwise affected by the hurricane.

The maximum amount of rainfall from Hurricane Frederic was 23 cm (9 inches) which fell in 24 h at Merrill, Mississippi. Mobile recorded 21.7 cm (8.55 inches) and Dauphin Island recorded 21.5 cm (8.45 inches) on 12 and 13 September 1979 (U.S. Army Corps of Engineers 1981).

Hurricane Camille caused an average of 12.7 cm (5 inches) of rain across most of its path, with a maximum recorded rainfall of 26.9 cm (10.6 inches) in Hattiesburg, Mississippi. Camille then brought heavy rains to Alabama and Tennessee before dumping nearly 68.6 cm (27 inches) of rainfall in West Virginia and Virginia (U.S. Army Corps of Engineers 1970).

Table 35. Hurricane surges in Alabama 1772-1979 (modified from U.S. Army Corps of Engineers 1967).

Date storm crossed coast	Landfall	Stage (ft above mean sea level)				
		Bayou La Batre (Biloxi quad)	Coden (Biloxi quad)	Dauphin Island (Biloxi quad)	Mobile (Mobile quad)	Gulf Shores (Pensacola quad)
Sept. 4, 1772					8.2	
Aug. 23, 1852					8.0	
Aug. 11, 1860					6.4	
Sept. 15, 1860					7.0	
July 30, 1870					7.0	
Aug. 19, 1888	Lake Charles, LA				7.2	
Oct. 2, 1893	Pascagoula, MS				8.4	4.9
Aug. 15, 1901	Grand Isle, LA				7.4	
Sept. 27, 1906	Mobile, AL		10.8		9.1	11.8
Sept. 20, 1909	Grand Isle, LA				7.0	
Sept. 14, 1912	Mobile, AL				4.4	
Sept. 29, 1915	Grand Isle, LA		10.0		6.4	
July 5, 1916	Gulfport, MS		10.8	7.7	10.8	11.3
Oct. 18, 1916	Pensacola, FL				3.2	
Sept. 28, 1917	Pensacola, FL				1.2	
Sept. 20, 1926	Pensacola, FL				4.5	
Sept. 1, 1932	Bayou La Batre, AL				4.5	
Sept. 10, 1944	Mobile, AL				3.8	
Sept. 19, 1947	New Orleans, LA	8.2	6.1		4.7	7.9
Sept. 4, 1948	Grand Isle, LA	6.0	6.0		4.4	
Aug. 30, 1950	Mobile, AL				3.9	
Sept. 24, 1956	Ft. Walton Beach, FL	6.3	6.3	3.3	2.2	5.8
Sept. 15, 1960	Pascagoula, MS			5.0	3.9	
Oct. 3, 1964	Franklin, LA	5.5		3.5	4.2	3.1
Aug. 17, 1969	Waveland, MS	8.5		9.2	7.4	9.1
June 19, 1972	Cape San Blas, FL				1.3	
Sept. 23, 1975	Ft. Walton Beach, FL					
Sept. 14, 1979	Dauphin Island, AL	9.5	10.56	13.84	8.5	16.2

U.S. GEOLOGICAL SURVEY HYDROLOGIC UNITS

A hydrologic unit is a geographic area representing part or all of a surface drainage basin or distinct hydrologic feature as delineated by the United States Geological Survey (USGS), Office of Water Data Coordination on the State Hydrologic Unit Maps. The USGS divides hydrologic areas into regions, subregions, accounting units, and cataloging units. Each hydrologic unit has an eight digit code, such as 03160205, the first two digits specifying region, the next two subregion, then accounting unit and cataloging unit.

The Mobile/Baldwin County study area lies within the South Atlantic-Gulf Region and includes four subregions (Escatawpa River, Tombigbee River/Mobile River/Mobile Bay, Alabama River, and Perdido Bay drainages) which are subdivided into a total of eight cataloging units, listed below (U.S. Geological Survey 1974, 1981). These hydrologic units are delineated on the Atlas sheets, along with the cataloging unit code.

03170008	Escatawpa River Basin
03170009	Western Coastal Unit
03160203	Tombigbee River Basin
03160204	Mobile River Basin
03160205	Mobile Bay Unit
03150204	Alabama River Basin
03140106	Perdido River Basin
03140107	Eastern Coastal Unit

STREAM AND RIVER DISCHARGE

Factors that control streamflow are of two basic types: meteorological and terrestrial. Meteorologic factors include precipitation, temperature, and wind. Terrestrial factors include topographic and geologic features and the geographic distributions of cultural features and vegetative cover. Since coastal Alabama is not a self-contained hydrologic unit, streams which flow through the area may be influenced to a greater or lesser degree by factors outside the immediate geographic area.

Runoff of precipitation is the source of all streamflow, and consists of two basic types; surface runoff and subsurface runoff. Surface runoff occurs immediately after it rains when the amount of rainfall has exceeded the combined rates of evaporation and ground infiltration. This direct runoff is transported to stream basins by running over the land surface or by interflow, the movement of water through the soil without entering the groundwater table. Factors important in determining direct runoff rates include drainage-basin area, land-surface slope and permeability of the ground surface.

Runoff also reaches streams by releases from ground water storage. Basin and bank storage are two components of this type of release. Bank storage

occurs when water rises above the water table and permeates the surrounding soil. Releases from bank storage occur when stream levels recede and is immediately available. Basin storage occurs in aquifers and the water is released more slowly.

The type of runoff governs natural streamflow characteristics. Streams dependent on direct or surface runoff tend toward wide fluctuations of streamflow while those dependent on ground-water releases are more stable.

Gaging stations and partial-record (not continuously monitored) stations operated by the USGS provide basic information on streamflow characteristics in coastal Alabama. Data collected include records of stage (water levels) and stream discharge (water volume passing a point within a given period of time). Mathematical analysis of the data allows different types of streamflow characteristics to be developed, such as annual discharge, average discharge, etc.

Gaging-station locations in Mobile and Baldwin Counties are presented on the atlas sheets. Table 36 lists the gaging stations by USGS station number and indicates where they are located by stream and atlas quad sheets. The table also indicates the average daily flow in million of gallons per day (mgd) and the median annual 7-day low flow in mgd.

The median annual 7-day low flow of a stream is the lowest mean discharge for seven consecutive days during a year. By comparing this low flow to the average flow, a stream's ability to assimilate wastes and dilute them in dry weather can be evaluated.

The monthly mean discharge of a stream can be used to evaluate changes in stream flow on a seasonal basis. Factors affecting seasonal streamflow include precipitation rates, water use, and hydrologic modifications, such as channelization and dams. The monthly mean discharge of streams in cubic feet per second (ft^3/s) in the Mobile River basin and in the Perdido Bay area are presented in Tables 37 and 38. Figure 15 illustrates the monthly mean discharge of the Alabama, Tombigbee, and Perdido Rivers.

Average flows can also be expressed as unit runoff in cubic feet per second per square mile ($ft^3/s/mi^2$), which is the average number of cubic feet of water flowing per second from each square mile of the drainage area. This figure of unit runoff can be utilized in comparing basins of unequal size since they are reduced to a common base of one square mile. Table 39 presents the duration of daily flow and average discharge (ft^3/s) at gaging stations in the study area. Average unit runoff in coastal Alabama varies from less than 2.0 $ft^3/s/mi^2$ to less than 2.5 $ft^3/s/mi^2$ (O'Neil and Mettee 1982).

Table 40 presents a summary of the watershed area of streams flowing through coastal Alabama and the mean annual discharge of these streams. The total mean annual discharge into Alabama estuaries is over 75,000 ft^3/s from a watershed area greater than 45,000 mi^2.

Table 36. Average daily flow and mean annual 7-day low flow at U.S. Geological Survey stations in coastal Alabama (modified from Reed and MaCain 1971, 1972 and O'Neil and Mettee 1982).

USGS	Stream	Quad	Average flow (mgd)[a]	Low flow (mgd)
		Perdido River Basin		
02376240	Dyas Creek	Bay Minette	71	6.2
02376500	Perdido River	Bay Minette	497	178
02377500	Styx River	Bay Minette	124	26
02377700	Styx River	Bay Minette	153	45
		Mobile River and Mobile Bay Basin		
02378410	Fish River	Bay Minette	44	21
02378500	Fish River	Bay Minette	79	39
02429605	Little River	Atmore	160	59
02429650	Majors Creek	Atmore	55	14
02470500	Mobile River	Atmore	39400	7750
02470610	Cedar Creek	Citronelle	88	12
02470800	Bayou Sara	Mobile	18	4.5
02470925	Chickasaw Creek	Mobile	71	62
02471000	Chickasaw Creek	Mobile	193	45
02471006	Eight Mile Creek	Mobile	42	26
02471065	Montlimar Creek	Mobile	15	2
02471078	Fowl River	Mobile	29	15
		Escatawpa River Basin		
02479450	Escatawpa River	Citronelle	324	10
02479468	Puppy Creek	Citronelle	40	4.4
02479500	Escatawpa River	Mobile	627	72
02480020	Big Creek	Mobile	100	21
02480037	Miller Creek	Mobile	52	21
02480150	Franklin Creek	Biloxi	23	8.4

[a]Million of gallons per day (mgd).

SURFACE WATER QUALITY

Surface-water quality is highly dependent on several factors. These include the chemical qualities of precipitation in an area, the soil and rocks which the precipitation comes in contact with, and the length of time the precipitation is in contact with the soil. Other factors affecting surface-water quality are point- and nonpoint-source municipal and

Table 37. Monthly mean discharges (ft^3/s) of streams in the Mobile River basin (Crance 1971).

Month	Alabama River[a]	Tombigbee River[b]	East Bassett Creek[c]	Chickasaw Creek[d]	Montlimer Creek[e]
January	36,772	38,854	344	342	23
February	54,267	54,422	531	370	23
March	65,267	67,908	521	389	18
April	60,547	62,353	449	452	22
May	32,241	26,048	208	199	16
June	18,620	9,111	184	231	15
July	16,992	9,028	185	234	18
August	13,192	3,852	94	254	16
September	13,051	4,023	120	194	12
October	14,251	5,142	118	179	15
November	16,646	9,741	208	217	13
December	31,234	22,074	326	238	17

[a] Alabama River at Clairborne, Alabama (Station Number: 02429500; Period of Record: 1955-1969).
[b] Tombigbee River near Leroy, Alabama (Station Number: 02470000; Period of Record: 1951-1960).
[c] East Bassett Creek at Walker Springs, Alabama (Station Number: 02470100; Period of Record: (1956-1969).
[d] Chickasaw Creek near Whistler, Alabama (Station Number: 02471000; Period of Record: 1956-1969).
[e] Montlimer Creek at U.S. Highway 90 at Mobile, Alabama (Station Number: 02471065; Period of Record: 1962-1967).

industrial waste discharges, the quality of these discharges, and the ability of the water body to assimilate and dilute these wastes. Factors affecting dilution characteristics are precipitation runoff in streams and the mixing and flushing actions of tides, currents, and winds in bays or estuaries.

Table 38. Monthly mean discharges (ft^3/s) of streams draining into Perdido Bay (Crance 1971).

Month	Perdido River[a]	Jacks Branch[b]	Styx River[c]
January	755	20	218
February	897	45	254
March	785	37	209
April	1,075	50	229
May	566	10	129
June	631	32	154
July	615	21	169
August	558	14	212
September	551	32	176
October	516	25	136
November	483	11	110
December	674	21	141

[a] Perdido River at Barrineau Park, Florida (Station Number: 02376500; Period of Record: 1954-1968).
[b] Jacks Branch near Muscogee, Florida (Station Number: 02376700; Period of Record: 1958-1962).
[c] Styx River near Loxley, Alabama (Station Number: 02377500; Period of Record: 1958-1969).

The chemical quality of water is characterized by concentrations of dissolved ions and suspended solids. The amount or occurrence of these constituents in water govern how the water may be utilized and thus may be considered as criteria for water quality and water use. The chemical quality of streams in coastal Alabama is often characterized by the mineral content (Tables 41 and 42). The total mineral content in water is referred to as total dissolved solids (TDS). In coastal Alabama most streams have a TDS of 100 milligrams per liter (mg/l) or less. The amount and type of dissolved solids determines water hardness, what type of industrial processes it is suitable for, and what chemicals or chemical reactions it must undergo before achieving desirable properties for particular uses.

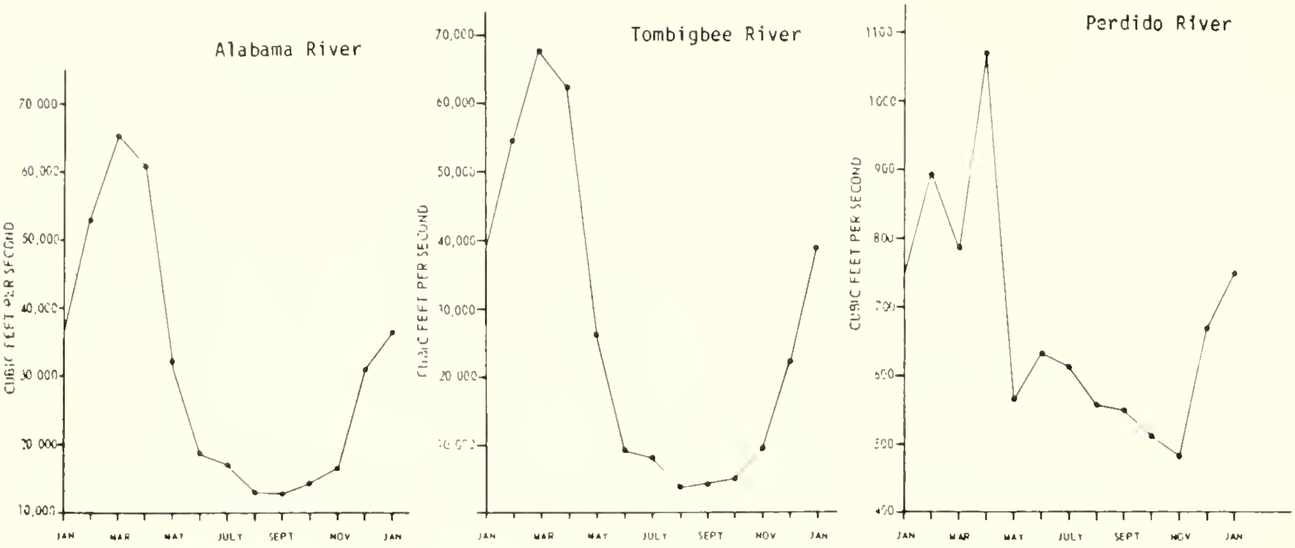

Figure 15. Monthly mean discharge of the Alabama, Tombigbee, and Perdido Rivers (after Chermock 1974).

Table 39. Duration of daily flow and average discharge (ft^3/s) at gauging stations in coastal Alabama (discharge which was equaled or exceeded for indicated percentage of time) (Riccio et al. 1973).

	USGS station number and location				
Percent of time	02376500 Perdido River at Barrineau Park, Fla. (1942-62)	02377500 Styx River near Loxley, Ala. (1952-62)	02378500 Fish River near Silverhill, Ala. (1954-62)	02471000 Chickasaw Creek[a] near Whistler, Ala. (1952-62)	02479500 Escatawpa River near Wilmer, Ala. (1946-62)
1	4,500	1,300	550	1,900	8,400
2	3,300	970	400	1,400	6,000
5	2,200	580	270	800	3,700
10	1,400	400	200	550	2,500
20	970	250	140	350	1,400
30	740	170	110	260	960
40	600	130	100	210	680
50	510	97	90	170	500
60	440	76	81	140	360
70	380	62	70	120	250
80	330	49	61	92	180
90	290	36	52	62	130
95	260	30	47	48	100
98	250	24	44	37	72
99	240	23	42	29	60
99.5	230	21	40	25	49
99.9	210	19	38	23	40
Average discharge					
ft^3/s	773	181	119	285	1,041
$ft^3/s/mi^2$	1.96	1.94	2.16	2.32	2.06

[a] Published now as "near Kushla."

Table 40. A summary of the watershed area of streams and their mean annual discharge into Alabama estuaries (Chermock 1974, modified from Crance 1971).

Estuary and[a] gauge station[1]	Mean annual discharge (ft^3)	Watershed area (mi^2)	Years of records
Mississippi Sound	200[c]	100[b]	
Mobile Bay			
Montlimer Creek 02471065	23.6	8.57	12
Fish River 02378500	107.0	55.1	15
Additional	600[c]	300[b]	
Total	730.6	363.67	
Mobile Delta			
Alabama River 02429500	31,870	22,000	38
Tombigbee River 02470000	36,230	19,100	32
East Basset Creek 02470100	276	188	12
Chickasaw Creek 02471000	275	125	30
Additional	3,715[c]	2,239[b]	
Total	72,366	43,652	
Perdido Bay			
Perdido River 02376500	765	394	40
Jacks Branch 02376700	27.1	23.2	3
Styx River 02377500	170	93.2	17
Additional	931	507.6	
Total	1,893.1	1,018.0	
Totals	75,189.7	45,133.67	

[a]Number after stream is U.S. Geological Survey station index number.
[b]Area estimated by Crance.
[c]Estimated.

Other criteria such as dissolved oxygen (DO), biochemical oxygen demand (BOD) and bacteria (fecal coliform) present in the water are also indicators of water quality. Low DO concentrations stress or kill fish and other aquatic organisms. BOD is a measure of the quantity of dissolved oxygen, generally in milligrams per liter, used for the decomposition of organic matter by microorganisms, such as bacteria. High BOD rates can result in low-level DO concentrations during periods of high bacterial growth. Fecal coliform concentrations are used as indicators of possible sewage pollution, with the attendant danger of disease transmission. Municipal sewage

Table 41. Chemical analyses of water from streams in Mobile County (Reed and McCain 1972).

Number (quad)	Stream name	Date of collection	Stream discharge mgd[b]	Dissolved substances (mg/l)[a]						
				Bicar-bonate HCO_3	Carbo-nate CO_3	Chlo-ride Cl	Hardness as $CaCO_3$: Calcium, magne-sium Ca^{++}, Mg^{++}	Hardness as $CaCO_3$: Noncar-bonate	pH	Tempera-ture (°C)
02470500 (Atmore)	Mobile River near Mt. Vern-on	10-06-66	--------	68	0	13	60	4	7.7	23
		04-05-67	--------	46	0	11	45	7	7.4	21
02470605 (Atmore)	Cedar Creek above Cedar Creek Falls	03-08-67	--------	2	0	30	18	16	5.6	--
02470607 (Citro-nelle)	Bull Branch near Citro-nelle	03-07-67	--------	4	0	3.6	5	2	5.2	--
02470610 (Citro-nelle)	Cedar Creek at Cedar Creek Falls	10-06-66	9.6	6	0	23	12	7	6.7	19
		03-08-67	--------	2	0	23	12	10	5.3	--
		04-05-67	24.8	4	0	23	15	12	6.6	21
02470800 (Biloxi)	Bayou Sara near Saraland	10-07-66	4.3	4	0	3.4	5	2	6.8	17
		04-06-67	8.1	4	0	3.2	2	0	6.7	18
02470910 (Mobile)	Chickasaw Creek near Gulfcrest	03-07-67	--------	4	0	5.6	5	2	6.0	--
		04-05-67	--------	6	0	4.2	8	3	6.3	19
		05-02-67	--------	4	0	4.4	8	5	5.7	--
02470925 (Mobile)	Chickasaw Creek at Chun-chula	10-07-66	12.7	6	0	2.6	5	0	7.3	17
		04-05-67	23.8	16	0	3.6	8	0	7.2	17
02471000 (Mobile)	Chickasaw Ck. near Whistler	09-15-65	78.9	4	0	6.6	5	2	7.3	23
		10-14-65	89.8	4	0	6.2	5	2	6.7	21
		11-17-65	74.3	4	0	3.6	12	9	6.7	16
		12-28-65	95	4	0	3.8	8	5	6.9	9
		02-17-66	763	2	0	3.8	5	3	6.6	13

		03-29-66	154	4	0	3.4	8	5	6.2	14
		05-10-66	80.1	4	0	3.6	8	5	7.2	19
		06-22-66	48.4	6	0	3.2	8	3	7.3	22
		07-27-66	60.6	4	0	3.2	12	9	7.5	24
		08-30-66	43.2	4	0	4.0	8	5	7.3	24
		10-07-66	35.4	14	0	3.4	8	0	7.1	18
		11-16-66	177	4	0	3.8	8	5	6.3	14
		12-28-66	96.9	4	0	4.0	5	2	5.8	8
		01-31-67	111	4	0	3.8	5	2	6.6	10
		03-13-67	93.7	4	0	3.4	8	5	6.1	19
		04-05-67	69.8	6	0	3.4	5	0	6.8	21
02471006 (Mobile)	Eightmile Ck. near Eight Mile	10-05-66	24.7	6	0	4.6	5	0	7.0	19
		04-05-67	29.5	12	0	4.6	10	0	7.5	21
02471065 (Mobile)	Montlimar Ck. at U.S. Hwy 90 at Mobile	09-14-65	13.6	16	0	8.0	30	17	7.2	26
		10-14-65	9.7	30	0	9.2	38	13	6.6	19
		11-17-65	9.7	46	2	7.0	45	4	8.3	17
		11-18-65	9.0	30	0	6.2	32	7	7.4	16
		12-30-65	9.7	24	0	7.0	28	8	7.2	14
		02-16-66	19.4	28	0	7.2	38	15	7.3	16
		03-29-66	15.5	26	0	6.8	35	14	7.3	18
		05-12-66	9.0	30	0	6.6	32	7	6.9	22
		06-22-66	11.0	36	0	5.4	40	10	7.3	26
		07-27-66	11.6	28	0	4.2	32	9	7.7	27
		10-05-66	11.0	28	0	6.6	26	3	7.2	26
		12-30-67	7.1	20	0	5.8	28	12	6.9	8
		01-31-67	11.6	24	0	6.4	25	5	7.0	14
		03-15-67	11.6	34	0	7.8	32	4	7.1	18
		04-06-67	7.6	22	0	6.0	22	4	7.3	22
02479447 (Citro-nelle)	Beaver Pond Branch at mouth	03-07-67	--------	0	0	256	132	132	4.5	---
		05-02-67	--------	0	0	175	90	90	4.3	---
02479450 (Citro-nelle)	Escatawpa River at County Rd. 96	10-06-66	10.0	2	0	51	30	28	5.2	19
		04-05-67	54.2	8	0	19	20	13	6.3	21
02479468 (Citro-nelle)	Puppy Creek near George-town	06-01-66	--------	2	0	24	15	13	7.4	21

(continued)

Table 41. (concluded)

Number (quad)	Station name	Date of collection	Stream discharge mgd[b]	Dissolved substances (mg/l)[a] Bicarbonate HCO_3	Carbonate CO_3	Chloride Cl	Hardness as $CaCO_3$ Calcium, magnesium Ca^{++}, Mg^{++}	Noncarbonate	pH	Temperature (°C)
		10-06-66	3.3	4	0	23	12	9	6.2	17
		03-07-67	--------	4	0	21	12	9	5.6	---
		04-05-67	8.1	4	0	29	20	17	6.4	17
		04-05-67	--------	2	0	29	18	16	5.2	23
		05-02-67	--------	2	0	13	10	8	5.5	22
02479500 (Mobile)	Escatawpa River near Wilmer	09-16-65	166	4	0	9.8	8	5	6.7	28
		10-14-65	128	4	0	10	12	9	6.8	---
		11-16-65	247	4	0	8.6	15	12	6.4	18
		12-28-65	301	2	0	7.2	10	8	6.3	8
		02-16-66	5,070	8	0	4.2	10	3	7.0	13
		03-29-66	340	2	0	6.6	8	6	6.7	15
		05-10-66	313	4	0	6.0	10	7	6.8	21
		06-22-66	89.8	4	0	7.8	10	7	7.0	24
		07-27-66	96.9	2	0	7.0	10	8	6.6	29
		08-30-66	99.5	4	0	7.8	10	7	7.2	24
		10-05-66	64.5	6	0	11	10	5	6.4	23
		11-18-66	291	4	0	9.2	8	5	6.1	16
		12-29-66	359	2	0	13	10	8	5.8	8
		01-30-67	415	4	0	7.4	8	5	6.1	12
		03-14-67	223	4	0	10	8	5	6.0	18
		04-04-67	209	6	0	8.8	8	3	6.4	22
02480020 (Mobile)	Big Creek near Seven Hills	10-05-66	19.6	6	0	3.0	2	0	6.4	21
		04-04-67	25.6	10	0	4.6	8	0	7.1	22
02480037 (Mobile)	Miller Creek near Dees	10-05-66	20.7	6	0	5.0	8	3	6.8	19
		04-06-67	23.9	8	0	5.4	8	1	6.9	18
02480150 (Biloxi)	Franklin Creek near Grand Bay	10-05-66	13.6	4	0	5.2	5	2	6.6	20
		04-06-67	18.2	8	0	6.4	8	1	7.0	18

[a] milligrams per liter
[b] million gallons per day

Table 42. Chemical analyses of water from streams in Baldwin County (Reed and McCain 1971)

Number (quad)	Station name	Date of collection	Stream discharge (mgd)	Dissolved substances (mg/l)			Hardness as $CaCO_3$		pH	Temperature (°C)
				HCO_3	CO_3	Cl	Ca^{++}, Mg^{++}	Noncarbonate		
02372640 (Bay Minette)	Dyas Creek near Dyas	10-04-66	7.7	4	0	3.6	5	2	7.0	17
02376500 (Bay Minette)	Perdido River near Barrineau Park	10-05-66	193	6	0	3.6	5	0	6.4	19
02377500 (Bay Minette)	Styx River near Loxley	09-14-65	88.5	4	0	8.0	10	7	6.3	24
		10-13-65	99.5	4	0	5.2	5	2	7.7	21
		11-17-65	69.8	2	0	4.6	10	8	7.1	17
		12-29-65	64.2	4	0	4.2	8	5	7.6	12
		02-15-66	378	2	0	4.6	8	6	7.4	13
		03-28-66	69.8	8	0	4.6	10	3	7.4	16
		05-11-66	30.3	4	0	4.0	5	2	7.2	19
		06-23-66	76.9	2	0	4.0	8	6	6.7	21
		07-26-66	89.2	2	0	3.4	5	3	7.2	26
		08-31-66	165	4	0	3.6	10	7	6.1	23
		10-05-66	34.6	4	0	3.8	2	0	7.1	22
		11-17-66	114	2	0	4.4	2	0	5.4	15
		12-29-66	118	2	0	4.4	8	6	5.7	7
02377550 (Bay Minette)	Hollinger Creek near Gateswood	10-05-66	23.8	6	0	7.8	5	0	6.3	23
02377975 (Bay Minette)	Blackwater River above Seminole	10-05-66	54.7	8	0	5.8	5	0	7.1	18
02378300 (Pensacola)	Magnolia River near Foley	10-04-66	14.4	8	0	6.6	10	3	6.4	19

(continued)

Table 42. (concluded)

Number (quad)	Station name	Date of collection	Stream discharge (mgd)	Dissolved substances (mg/l)						pH	Temperature (°C)
							Hardness as $CaCO_3$				
				HCO_3	CO_3	Cl	Ca^{++}, Mg^{++}	Noncarbonate			
02378410 (Bay Minette)	Fish River near Daphne	10-04-66	22.0	4	0	4.8	2	0		7.4	19
02378500 (Bay Minette)	Fish River near Silver Hill	09-14-65	50.0	12	0	6.0	22	12		6.8	22
		10-13-65	63.5	4	0	6.4	10	7		6.3	20
		11-17-65	53.3	4	0	5.2	12	9		7.3	18
		12-30-65	50.9	6	0	5.2	10	5		7.6	15
		02-15-66	91.1	4	0	5.8	8	5		7.7	14
		03-28-66	53.3	10	0	4.8	8	0		7.5	17
		05-11-66	46.0	4	0	4.0	8	5		7.3	18
		06-21-66	43.2	6	0	4.0	8	3		6.9	21
		07-26-66	52.5	6	0	4.0	10	5		7.2	22
		08-31-66	82.1	2	0	3.4	8	6		6.5	22
		10-04-66	41.9	4	0	5.0	5	2		6.2	19
		11-17-66	56.4	6	0	4.8	5	0		6.0	13
		12-29-66	66.6	4	0	4.8	5	2		6.0	8
02429605 (Atmore)	Little River near Little River	10-04-66	63.1	6	0	4.0	5	0		7.3	19
02429628 (Atmore)	Turkey Creek near Blacksher	10-04-66	3.9	4	0	4.0	2	0		6.3	17
02429650 (Atmore)	Majors Creek near Tensaw	10-04-66	13.2	6	0	3.2	5	0		6.4	20
02471033 (Bay Minette)	Bay Minette Creek near Stapleton	10-04-66	14.5	4	0	11	5	2		6.5	18
02471036 (Bay Minette)	Whitehouse Creek near Bromley	10-04-66	3.6	4	0	6.0	4	1		6.9	17
02470500 (Atmore)	Mobile River near Mount Vernon	10-06-66	-------	66	0	13	60	4		7.7	23
		04-05-67	-------	46	0	11	45	7		7.4	21

treatment plants and industrial point sources in coastal Alabama are shown in Figures 16 and 17 and listed in Tables 43 and 44, respectively. These plants and point sources are also located on the socioeconomic atlas sheets.

The Alabama Department of Environmental Management (ADEM) has classified surface water supplies in coastal Alabama into seven categories based on their suitability for particular uses. Table 45 lists the water use categories and the classification criteria. Major streams and water bodies on the atlas sheets are mapped according to their water-quality classifications. It should be noted that some uses are not mutually exclusive and mapped categories reflect this.

In addition to classifying surface-water supplies, the ADEM is also responsible for monitoring changes in water quality and determining when violations in water-quality standards occur. Water-quality data collected (1974-1979) by the ADEM in coastal Alabama from monitoring stations is presented in Table 46. Data for 1980-81, when the reporting format was changed to trend indication rather than specific data reports, is shown in Table 47. ADEM monitoring stations are located on the atlas sheets by station designation.

Water quality management plans (known as 208 studies after the applicable section in the Clean Water Act of 1977) attempt to identify sources of water pollution, assess their relation to state water quality criteria and establish plans and strategies to reduce undesirable situations. The Mobile 208 study is a water-quality analysis of major streams in the Mobile and Baldwin County area, conducted by the South Alabama Regional Planning Commission (SARPC) in 1976. During the study, additional water quality data were deemed desirable for greater areal coverage than were available from existing sources. Thirty-three sampling sites were established and five samples were taken during various seasons representing high stream flow, low flow, and high rainfall. Samples were taken at midwater column or maximum 5-foot depth. Data collected are summarized in Table 48; station locations are mapped on the atlas sheets.

Other agencies which have collected data on water quality in Mobile and Baldwin Counties include the U.S. Army Corps of Engineers, the Environmental Protection Agency (EPA), the USGS and various institutions and private concerns.

Water Quality Assessment

The following water quality summary is taken primarily from Ricco et al. (1973), O'Neil and Mettee (1982), U.S. Army Corps of Engineers (1983), Pierce and Rodgers (1966), and the South Alabama Regional Planning Commission (1979).

Mobile River Basin. The water quality of the Mobile River is dependent upon the water quality of its two major tributaries, the Alabama and Tombigbee Rivers. These two rivers are generally low in total dissolved solids and have good water quality. At higher flows, the Mobile River quality becomes much the same as that of the Tombigbee. The Mobile River

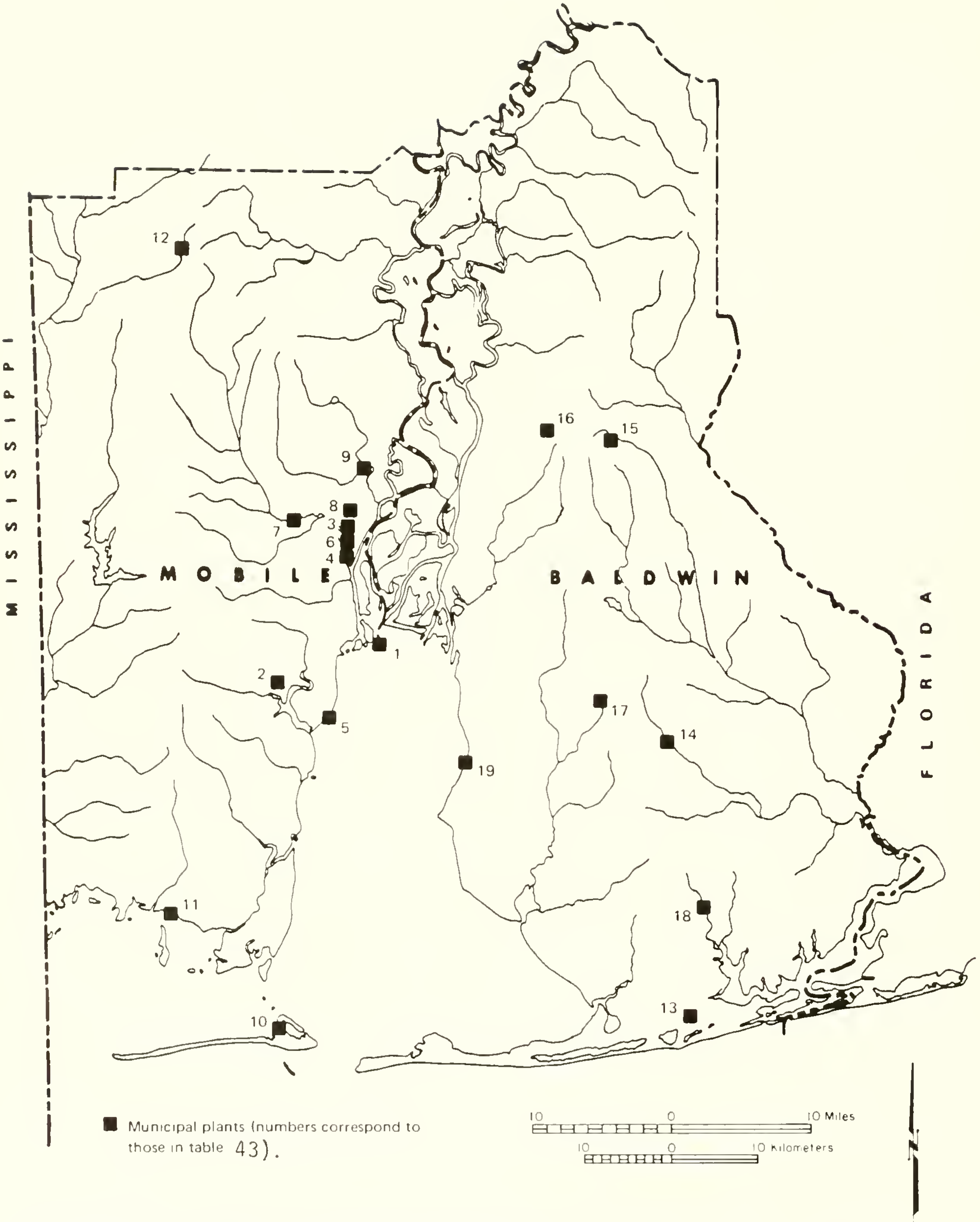

Figure 16. Location of municipal wastewater treatment plants (O'Neil and Mettee 1982).

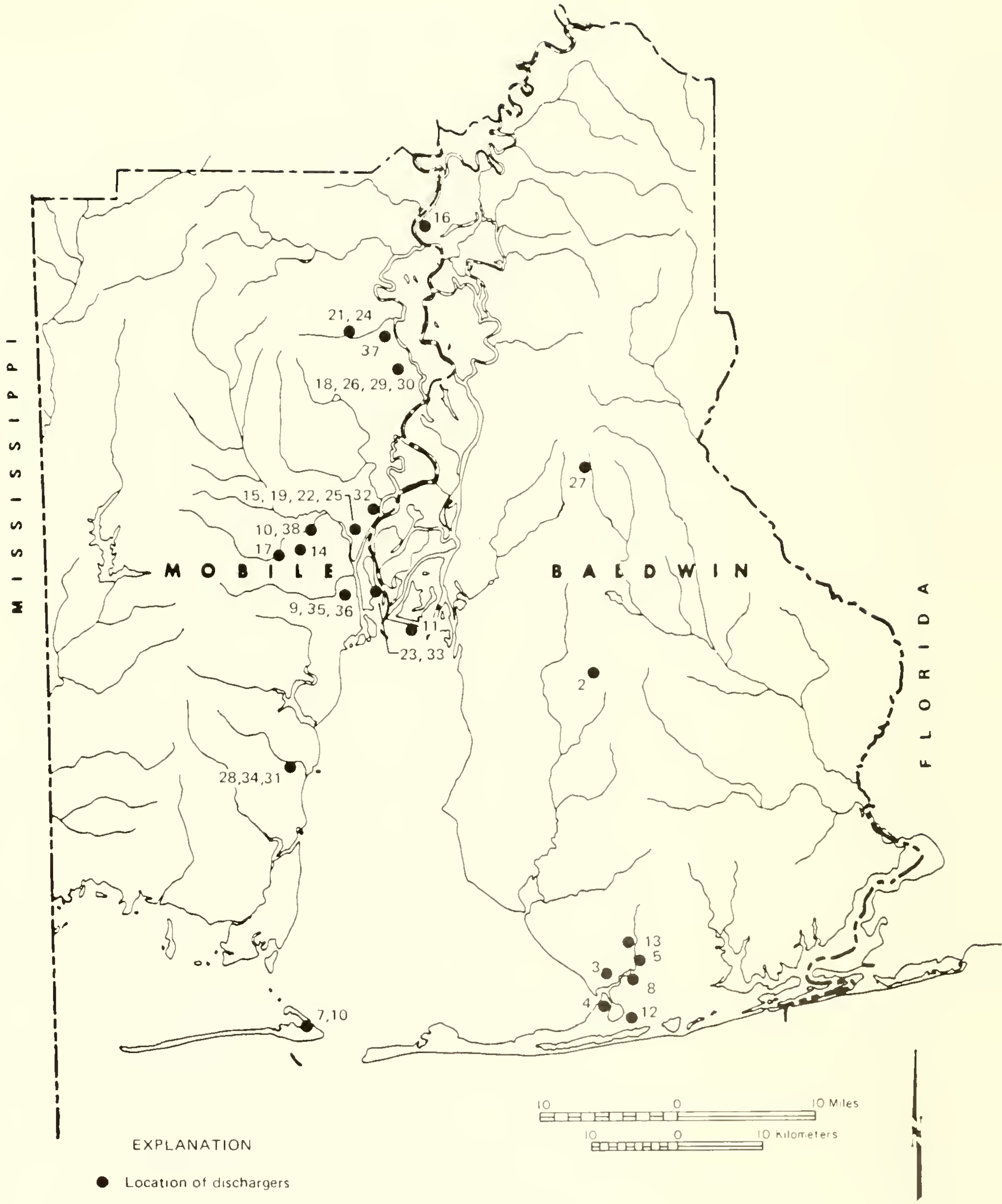

Figure 17. Location of industrial discharge points in Mobile and Baldwin Counties (O'Neil and Mettee 1982).

Table 43. Existing municipal sewage plants, 1977 (Brady 1979, O'Neil and Mettee 1982).

Number[a]	Plant	Treatment Description	Design flow (mgd)[b]	Receiving water
	MOBILE COUNTY			
1	McDuffie Island/Mobile[c]	High-rate activated sludge	16.00	Mobile Bay
2	Halls Mill Creek/Mobile[d]	High-rate trickling filter	1.50	Halls Mill Creek
3	Three Mile Creek/Mobile	High-rate trickling filter	10.00	Spring Branch
4	Hog Bayou/Mobile	Package Plant	0.35	Hog Bayou
5	Bill Ziebach/Mobile	High-rate trickling filter	2.00	Mobile Bay
6	Grover Street/Prichard	Two-stage trickling filter	4.00	Three Mile Creek
7	Eight Mile/Prichard	High-rate trickling filter	1.50	Eight Mile Creek
8	Chickasaw lagoon	Two single-stage lagoons	1.50	Chickasaw Creek
9	Saraland	Conventional activated sludge	0.59	Norton Creek
10	Dauphin Island	Standard-rate trickling	0.25	Aloe Bay
11	Bayou La Batre	Convertional activated sludge	1.00	Portersville Bay
12	Citronelle	Single-stage lagoon	0.22	Puppy Creek
	BALDWIN COUNTY			
13	Gulf Shores	Three-stage lagoon	0.33	Intracoastal Waterway
14	Robertsdale	Extended-aeration activated sludge	0.25	Rock Creek
15	Bay Minette	Primary clarification	1.00	Hollingers Creek
16	Westside lagoon/Bay Minette	Two-stage lagoon	0.225	Martin Branch
17	Loxley lagoon	Three-stage lagoon	0.16	Corn Branch
18	Foley lagoon	Single-stage lagoon	0.27	Wolf Creek
19	Fairhope	Step-aeration activated sludge	2.00	Mobile Bay

[a] For locations see Figure 16.
[b] Million gallons/day.
[c] Currently being converted to a 28 Mgal/d pure oxygen A.S. process.
[d] Will be closed in 1978.

Table 44. Flow summary of industrial process wastewater discharges, 1979 (Brady 1979, O'Neil and Mettee 1982).

Number[a]	Company	Flow (mgd)[b]
1	Barber Pure Milk	0.05
2	SARS	0.02
3	Aquila Seafood	0.001
4	Plashes Seafood	0.003
5	Grass Seafood	0.001
6	Gulf Shrimp	0.010
7	Mallon Seafood	0.0005
8	Oyster Bay Seafood	0.001
9	Star Fish & Oyster	0.288
10	Patronas Seafood	0.001
11	Causeway Seafood	0.001
12	Gulf Coast Knight Seafood	0.013
13	Bon Secour Fisheries	0.014
14	Crown Zellerbach	0.010
15	International Paper	33.2
16	Scott Paper	42.43
17	Stone Container	0.02
18	Stauffer Chemical-LaMoyne	1.10
19	Diamond Shamrock	0.06
20	Union Carbide-Chickasaw	3.634
21	Halby	0.0025
22	American Cyanamid	0.0600
23	ALCOA	0.8000
24	Virginia	0.2000
25	Eagle Chemical	0.2250
26	Courtaulds of North America	8.80
27	Reichhold Chemical	0.1900
28	Degussa	0.3710
29	Shell Chemical	1.044
30	Stauffer Chemical Cold Creek	0.400
31	Marion Refinery	0.0453
32	Louisiana Land & Exploration	0.110
33	Chevron Asphalt	0.350
34	Airco Alloys	0.354
35	Frisco Railroad	0.000325
36	I.C.G. Railroad	0.0115
37	Alabama Power-Barry Steam Plant	40.0
38	Thompson-Hayward	0.0041

[a] For locations see Figure 17.
[b] Million gallons/day

Table 45. Water quality classification criteria (South Alabama Regional Planning Commission 1979).

PUBLIC WATER SUPPLY

pH: 6.0-8.5

Temperature: 90 °F maximum (32.2 °C)
5 °F maximum rise above natural, in-stream temperatures except for coastal waters or estuarine waters. For coastal or estuarine waters, a 4 °F maximum rise above natural in-stream temperature, except 1.5 °F maximum rise in the period June through September.

Dissolved Oxygen (DO): 5.0 mg/l

Fecal Coliform: 2000/100 ml, geometric mean, monthly average
4000/100 ml, maximum in any sample

Turbidity: 50 Jackson turbidity units

SWIMMING AND OTHER WHOLE BODY WATER-CONTACT SPORTS

Same as Public Water Supply with the following exception:

pH: 6.5-8.5 for estuarine and salt waters

Fecal Coliform: 100/100 ml, geometric mean
200/100 ml, maximum in any sample

SHELLFISH HARVESTING

Same as Public Water Supply with the following exceptions:

pH: 6.5-8.5 for estuarine and salt waters

Fecal Coliform: 14/100 ml, geometric mean
43/100 ml, 10% of samples cannot exceed

FISH AND WILDLIFE

Same as Public Water Supply with the following exceptions:

pH: 6.5-8.5 for estuarine and salt waters

Fecal Coliform: 1000/100 ml, geometric mean
2000/100 ml, maximum in any sample

(continued)

TABLE 45. (concluded)

AGRICULTURAL AND INDUSTRIAL WATER SUPPLY

pH: 6.0-8.5
6.5-8.5 for estuarine and salt waters

Temperatures: 90 °F maximum (32.2 °C)
5 °F maximum rise in streams, lakes, and reservoirs

DO: 3.0 mg/l

Turbidity: 50 Jackson units

INDUSTRIAL OPERATIONS

Same as Agricultural and Industrial Water Supply

NAVIGATION

Same as Agricultural and Industrial Water Supply with the following exception:

DO: 2.0 mg/l

near Mt. Vernon has a calcium-magnesium bicarbonate-type water at both low and high flows (Table 48). Most other chemical constituents increase at low flows (Ricco et al. 1973).

The Mobile River is affected by saltwater intrusion from Mobile Bay, occurring as a wedge of saltwater on the bottom of the river which, at times, extends more than 20 mi upstream from the river mouth. The wedge occurs because of the difference in temperature and densities of freshwater and saltwater. The length and amount of the intrusion is influenced by stream flow and tidal actions. At high tides and low stream flow the wedge is more extensive and salinities are higher. At high stream flow or flood conditions the wedge may be pushed out into Mobile Bay and the bay waters may become more riverlike (Moser and Chermock 1978). Although most streams flowing into saltwater bodies are affected by intrusion, as it is a naturally occurring phenomenon, the navigation channel in the Mobile River increases the effect.

The average and low-flow conditions of the Mobile River system will be altered upon completion of the Tennessee-Tombigbee Waterway. Projections indicate that with full development of the waterway, the average flow could be increased as much as 1,560 ft^3/s, with low flows increasing as much as 250 ft^3/s (U.S. Army Corps of Engineers 1983). This could influence saltwater intrusion in the Mobile River and may also affect salinities in the Mobile River and in Mobile Bay. Apparently, the most probable effect would be to lower salinities in both the river and the bay.

Table 46. Average and maximum-minimum values of selected water-quality parameters, 1974-1979 (Alabama Department of Environmental Management 1980).

Station (quad sheet)	Water temp. (°F)			Dissolved oxygen (mg/l)			BOD_5 (mg/l)[a]			Turbidity (Jackson units)			pH		
	min	mean	max	min	mean	max	min	mean	min	min	mean	max	min	mean	max
							Escatawpa River Basin								
Station E-1 Escatawpa River (Mobile)															
1974	50.0	66.2	84.2	6.5	7.8	10.1	0.0	1.2	2.0	4.0	9.4	25.0	5.4	5.8	7.2
1975	46.0	66.8	80.6	6.1	8.1	10.4	0.0	1.3	3.0	4.5	7.5	11.0	3.8	4.9	6.2
1976	49.0	67.6	81.0	6.3	8.7	11.3	0.5	1.4	3.0	1.5	5.6	12.0	4.8	6.0	7.4
1977	40.0	64.9	82.0	6.2	8.7	12.1	0.5	1.2	3.0	2.9	8.4	35.0	4.8	5.8	6.6
1978	43.0	64.7	80.0	6.0	8.5	11.9	0.1	1.4	4.4	2.9	6.9	12.0	3.7	5.5	6.2
1979	43.0	61.7	77.0	6.3	8.3	11.8	0.7	1.0	2.1	3.7	8.4	17.0	4.2	5.0	5.7
							Mobile River Basin								
Station BLB-1 Bayou La Batre (Biloxi)															
1974	55.4	70.5	86.0	3.2	4.0	5.8	0.0	3.9	13.0	3.0	6.0	12.0	6.0	6.8	7.9
1975	49.0	68.5	84.2	0.0	1.7	4.5	0.6	3.1	10.0	3.0	8.6	22.0	4.5	6.2	6.9
1976	54.0	71.7	86.0	1.5	4.7	7.8	0.0	1.6	3.6	2.2	5.9*	11.0	5.7	6.4	7.0
1977	44.5	67.2	84.0	0.8	3.9	6.6	0.8	2.7	5.6	2.2	7.8	26.0	5.8	6.4	6.9
1978	50.0	68.6	80.0	2.5	4.9	8.0	0.3	1.3	3.6	3.0	11.8	60.0	5.8	6.6	7.7
1979	46.0	64.3	82.4	0.5	4.5	10.0	0.4	1.5	2.4	3.2	8.0	22.0	4.9	6.3	7.2
Station BS-1 Bon Secoure River (Pensacola)															
1974	53.6	72.3	87.8	2.6	6.9	9.0	0.2	2.5	4.4	4.0	5.4	7.0	7.3	7.6	7.9
1975	59.0	72.4	84.2	5.2	7.3	12.2	0.9	2.5	4.0	3.4	16.8	88.0	6.1	6.8	7.5
1976	48.0	70.2	86.0	5.5	7.6	10.7	0.9	3.3	7.4	2.9	9.1	13.0	6.9	7.5	8.1
1977	39.0	69.3	87.8	5.3	8.4	12.3	1.9	4.3	10.8	4.3	8.2	17.0	6.0	7.4	8.6
1978	39.0	68.2	82.4	4.5	6.9	11.0	1.4	2.7	4.9	3.0	7.9	14.0	6.8	7.4	8.1
1979	47.0	69.2	86.0	4.5	7.7	12.4	1.0	2.7	6.3	3.0	17.5	58.0	6.1	7.5	8.4

Station CS-1 Chickasaw Creek (Mobile)															
1974	51.8	70.2	82.4	5.7	6.6	8.3	0.5	1.6	2.5	3.0	5.2	8.0	5.9	6.4	6.7
1975	53.0	70.0	86.0	4.8	7.3	9.3	1.0	7.3	12.0	4.0	6.0	9.0	4.6	6.0	7.6
1976	44.0	68.3	88.0	1.3	5.7	9.5	0.7	2.1	3.8	2.8	6.8	11.0	3.5	6.2	7.2
1977	42.0	65.7	89.6	1.2	6.7	12.0	0.6	2.0	4.4	3.7	15.0	45.0	4.7	6.2	6.7
1978	44.0	69.6	85.0	2.0	6.2	8.9	0.7	2.0	4.3	2.3	6.8	16.0	5.6	6.2	7.3
1979	48.0	65.1	84.0	2.4	6.8	11.0	0.5	1.4	2.5	4.0	12.9	56.0	5.3	5.9	7.1
Station CS-2 Chickasaw Creek (Mobile)															
1974	52.7	76.8	93.2	0.1	3.0	9.3	1.0	10.7	26.0	12.0	15.8	22.0	6.3	6.8	7.3
1975	57.0	76.7	93.2	1.1	4.4	7.5	3.0	9.3	23.0	11.0	19.7	42.0	5.2	6.1	6.8
1976	60.0	77.4	94.0	0.0	3.0	7.2	4.0	12.7	23.8	10.0	20.6	32.0	4.5	6.2	6.9
1977	60.0	76.5	91.0	1.2	3.1	4.5	5.6	14.2	24.2	8.5	16.0	38.0	5.8	6.4	6.9
1978	42.0	75.7	92.0	0.5	4.6	10.6	1.0	4.4	11.8	4.2	15.5	38.0	6.2	6.8	7.7
1979	50.0	70.8	88.0	2.8	5.8	10.2	0.8	2.9	6.2	10.2	29.1	96.0	6.4	6.9	7.4
Station DR-1 Dog River (Mobile)															
1974	53.6	73.9	87.8	3.8	5.1	8.8	3.6	6.8	12.8	5.0	10.2	15.0	6.7	7.2	8.1
1975	60.8	74.9	86.0	3.1	6.8	10.9	2.0	4.3	10.2	7.0	12.8	20.0	5.6	6.8	8.7
1976	51.0	73.1	88.0	4.8	8.4	11.9	0.9	4.2	6.9	6.1	11.4	31.0	6.2	7.2	8.8
1977	46.0	70.6	87.8	2.7	6.5	14.3	1.6	4.5	10.0	6.8	14.0	24.0	6.2	6.9	8.4
1978	48.0	69.8	85.0	1.4	6.0	9.6	2.0	4.5	6.7	0.0	16.5	35.0	6.3	7.0	7.4
1979	46.0	66.9	84.0	0.4	7.0	13.6	2.4	4.8	10.0	6.5	16.8	50.0	6.3	7.0	8.2
Station MO-1a Mobile River (Bay Minette)															
1976	46.0	69.5	86.0	5.5	7.6	10.1	0.3	1.5	2.3	10.0	23.0	45.0	6.0	6.8	7.2
1977	43.0	68.2	88.0	5.2	7.5	11.1	0.4	1.3	3.6	6.0	23.3	50.0	6.0	7.0	7.7
1978	46.0	72.8	90.0	5.4	6.8	11.3	0.2	1.1	2.2	8.3	16.8	40.0	6.5	7.1	7.5
1979	46.0	60.8	88.0	6.2	8.2	11.8	0.4	1.1	2.5	9.5	40.4	93.0	6.6	7.0	7.4

(continued)

Table 46. (concluded)

Station (quad sheet)	Water temp. (°F)			Dissolved oxygen (mg/l)			BOD_5 (mg/l)[a]			Turbidity (Jackson units)			pH		
	min	mean	max	min	mean	max	min	mean	min	min	mean	max	min	mean	max
Station MO-2 Mobile River (Mobile)															
1974	52.7	71.8	86.0	4.5	5.9	9.3	0.0	1.1	2.0	8.0	12.4	17.0	6.9	7.4	7.6
1975	51.8	68.4	84.2	4.2	6.9	9.0	1.0	1.9	6.0	10.0	21.2	60.0	6.3	6.7	7.0
1976	43.0	69.1	84.0	3.9	6.2	9.2	0.4	1.8	3.6	4.1	17.7	52.0	6.1	6.8	7.7
1977	44.0	67.2	82.0	3.3	6.8	11.1	0.9	1.4	2.4	5.7	16.9	50.0	6.4	6.9	7.4
1978	46.0	72.5	88.0	3.0	7.0	12.3	0.2	1.3	3.0	2.7	12.4	32.0	6.5	7.2	8.0
1979	46.0	67.4	88.0	3.4	7.1	11.0	0.3	1.2	2.1	8.3	31.1	110.0	6.6	7.1	7.5
Station TM-1 Three Mile Creek (Mobile)															
1974	55.4	73.9	86.0	1.5	3.3	6.4	3.8	8.1	12.0	5.0	12.6	28.0	6.5	6.9	7.6
1975	56.5	74.6	86.0	0.3	1.8	4.6	2.0	5.5	13.0	4.0	11.3	23.0	6.2	6.2	6.9
1976	50.0	71.5	85.0	0.5	2.3	7.6	1.1	6.5	14.2	4.3	16.6	33.0	6.4	6.8	7.2
1977	47.0	69.6	89.6	0.0	2.5	6.2	5.1	14.9	60.0	5.8	19.7	46.0	6.3	6.8	7.4
1978	51.8	69.8	83.0	0.0	2.0	5.7	7.6	13.1	21.0	9.0	23.2	49.0	6.1	6.9	7.8
1979	48.0	66.1	82.0	0.0	1.7	8.7	1.9	10.0	25.4	10.3	32.3	100.0	6.1	6.7	7.4
Station TE-1 Tensaw River (Bay Minette)															
1976	46.0	68.6	84.0	5.9	7.8	10.7	0.3	1.6	4.8	9.4	19.1	42.0	6.3	7.0	7.5
1977	42.0	67.3	84.0	5.3	7.9	12.2	0.2	1.1	1.8	8.0	19.3	45.0	6.4	7.0	7.6
1978	46.0	72.3	90.0	5.3	7.4	11.0	0.2	0.9	1.6	6.9	14.4	34.0	6.7	7.3	7.7
1979	46.0	67.1	86.0	6.2	8.1	11.3	0.6	1.3	2.4	8.5	31.1	77.0	6.3	7.0	7.6
Station TE-2 Tensaw River (Bay Minette)															
1976	46.0	69.2	85.0	5.6	7.8	10.8	0.3	1.4	2.5	8.9	18.1	35.0	6.2	7.0	7.4
1977	42.0	67.6	85.0	5.0	7.9	12.0	0.3	1.2	2.3	5.7	18.3	40.0	6.2	7.0	7.5
1978	46.0	72.6	93.0	5.6	7.3	10.9	0.3	1.2	2.2	6.0	13.9	35.0	6.6	7.3	8.6
1979	46.0	66.9	86.0	6.0	8.0	11.2	0.4	1.1	2.4	8.4	30.6	78.0	6.5	7.0	7.5

Perdido - Escambia River Basin

Station HO-1 Hollinger Creek (Bay Minette)															
1974	44.6	61.9	75.2	0.4	3.4	7.5	2.2	4.1	6.5	6.0	10.8	15.0	5.9	6.5	6.8
1975	51.8	66.2	78.0	1.1	3.3	6.8	6.1	74.5	140.0	10.0	37.4	240.0	7.3	7.6	7.9
1976	44.0	62.4	75.0	0.2	2.4	6.3	1.6	10.1	32.0	5.5	10.1	25.0	6.4	6.8	7.2
1977	38.0	61.8	72.0	1.0	3.3	8.0	2.1	5.7	8.8	5.2	7.4	12.0	6.0	6.6	7.0
1978	42.0	65.2	86.0	0.7	3.2	9.2	1.1	6.0	12.8	8.0	19.2	55.0	5.0	6.4	7.0
1979	46.0	63.6	78.0	1.0	3.0	8.0	1.0	3.8	7.4	6.1	9.9	15.0	5.7	6.5	7.4
Station IC-1 Intracoastal Waterway (Pensacola)															
1974	52.7	69.9	86.0	1.8	6.2	10.0	1.6	2.1	2.6	4.0	6.6	10.0	7.4	7.6	7.9
1975	59.0	71.9	83.3	5.3	6.9	10.3	1.0	1.7	3.0	5.5	11.1	37.0	6.0	6.9	7.3
1976	50.0	69.5	87.0	4.5	7.2	9.7	0.6	2.5	4.5	3.2	7.1	12.0	6.2	7.5	8.2
1977	38.0	68.9	86.0	4.5	7.5	12.0	1.7	2.8	4.2	3.0	8.2	13.0	6.0	7.4	8.4
1978	42.0	69.0	84.2	4.5	6.9	11.0	1.0	2.0	3.7	2.5	17.2	52.0	6.6	7.4	7.9
1979	45.0	69.2	89.0	4.2	7.3	11.5	1.0	2.6	4.4	2.0	9.4	28.0	6.8	7.6	8.2
Station WO-1a Wolf Creek (Pensacola)															
1977	50.0	64.6	79.0	5.0	6.9	8.6	0.5	1.2	2.5	1.0	5.1	13.0	6.0	6.5	7.1
1978	44.0	65.8	80.0	5.0	6.6	7.8	0.3	1.1	2.6	2.0	25.2	66.0	5.8	6.3	7.2
1979	50.0	64.6	76.0	5.8	6.9	9.0	0.2	0.9	1.8	2.0	3.9	9.1	5.7	6.3	7.8

[a] Milligrams per liter (mg/l).

Note: Sample frequency is once a month. Dissolved oxygen is sampled at 5 ft if water is over 10 ft deep, otherwise at middepth of column. Temperature is sampled at 5 ft if water is over 10 ft deep, otherwise at surface. All other parameters are sampled at surface.

Table 47. Water-quality trends in Baldwin and Mobile Counties, 1980-81 (Alabama Department of Environmental Management 1982).

Station	Dissolved oxygen		pH		Water temperature		Turbidity		BOD_5
	Escatawpa River Basin								
E-1	0	nc	0	nc	0	nc	0	nc	nc
	Mobile River Basin								
BLB-1	2	nc	1	nc	1	nc	0	nc	nc
BS-1	1	nc	1	nc	0	nc	0	nc	nc
CS-1	1	nc	2	nc	1	nc	0	nc	nc
CS-2	1	nc	1	nc	0	nc	0	nc	nc
DR-1	1	nc	1	nc	1	nc	1	nc	--
MO-1a	0	nc	1	nc	0	nc	0	nc	nc
MO-2	1	nc	1	nc	9	nc	0	nc	nc
TM-1	3	nc	0	nc	1	nc	0	nc	nc
TE-1	0	nc	1	nc	0	nc	0	nc	nc
TE 2	0	nc	0	nc	0	nc	0	nc	nc
	Perdido - Escambia River Basin								
HO-1	2	nc	1	nc	0	nc	0	nc	--
IC-1	1	nc	1	nc	1	nc	0	nc	nc
WO-1a	1	nc	1	nc	0	nc	0	nc	nc

Degree of Pollution
0 - No violations
1 - Minor Violations (1%-25%)
2 - Moderate Violations (26% - 50%)
3 - Severe Violations (51%-100%)

Trends
+ - Improving
-- - Degrading
nc - No Change

Table 48. Mobile Section 208 study: summary of water quality data (modified from Alabama Regional Planning Commission 1979).

	Temp (°C)	DO (mg/l)	BOD_5 (mg/l)	Fecal coliform (no/100 ml)	Nitrite (mg/l)	Nitrate (mg/l)	Ammonia (mg/l)	Organic nitrogen (mg/l)
BOUNDARY SITES (Sites 1 through 8)[a]								
Maximum	29.5	8.1	3.4	234	0.48	0.011	0.60	0.80
Minimum	17.0	4.1	0.5	1	0.01	0.005	0.025	0.03
BAY SITES (Sites 9 through 13, 39 through 41)[a]								
Maximum	31.0	9.2	6.9	300	0.26	0.011	0.09	1.30
Minimum	15.7	3.9	0.6	1	0.01	0.005	0.023	0.014
STREAM SITES (Sites 14 through 38)[a]								
Maximum	30.0	9.9	14.0	6800	2.1	0.037	2.50	1.20
Minimum	12.2	0.9	0.2	2	0.01	0.005	0.025	0.014

[a]See atlas quad sheets for location.

Water quality of the Mobile River above its confluence with Chickasaw Creek is generally good, although fecal coliform levels are high during periods of high flows (generally in the winter months) and power plant cooling water discharges increase temperature levels. Below the entrance of Chickasaw Creek (Mobile quadrangle) water quality tends to be lowered somewhat, because of the greater loads of municipal waste water and industrial wastes contributed by Chickasaw Creek, Norton Creek, and Threemile Creek (Mobile quadrangle) (Table 46). The combined municipal and industrial waste discharge into these streams is 68 mgd (SARPC 1979). Offsetting these high waste loads is the greater absorbtive capacity of the Mobile River for oxygen-consuming wastes. Comparing water quality (DO and BOD) from stations above and below these creeks' confluences (Table 46) indicates that they have a moderate influence on these aspects of water quality (U.S. Army Corps of Engineers 1983). However, this influence combined with salt levels, fecal coliform counts, temperature and turbidity in this segment of the river reduces it to an Agricultural and Industrial classification use only (Table 46).

Mobile Bay. Bacterial and viral pollution can be a serious problem in Mobile Bay. When significantly high (14 most probable number per 100 milliliters (MPN/100 ml)) levels of bacterial pollution occur, oyster-reef closures are necessary, causing direct economic losses to the area's economy. The pollution of estuaries by bacteria in Alabama can be attributed primarily to municipal and industrial wastes (Chermock 1974). Gallagher et al. (1969) reported that the most significant source of these pollutants in Mobile Bay was the Mobile metropolitan area via the Mobile River. Measurements made during flood stage at the mouth of the river ranged from 11,000 to 150,000 MPN/100 ml. Approximately 77% to 97% of this total was attributed to

Table 48. (concluded).

TKN (mg/l)	Oil and grease (mg/l)	Total dissolved solids (mg/l)	Total lead (mg/l)	Total zinc (mg/l)	Total phosphorus (mg/l)	Chlorophyll a (mg/l)
1.01	1	24,600	0.01	0.036	0.13	10
0.08	1	76	0.01	0.011	0.034	2
0.54	1	18,000	0.01	0.074	0.17	17
0.044	1	83	0.01	.01	0.030	1
3.20	1	15,900	0.01	0.049	0.062	33
0.039	1	18	0.01	0.01	0.018	1

discharge from metropolitan Mobile. However, Gallagher (1969) also concluded that even if the Mobile effluent was entirely eliminated, sources upstream would probably raise bacterial levels above closure criterion levels. Closures of oyster reefs to harvesting has increased since 1950 and the periods of closure are longer. At present over 26,000 acres are permanently closed in northern Mobile Bay for harvesting of oysters. The sanitary water quality standards for oyster harvesting is exceeded most frequently during the winter and spring months when the Mobile River has high flows. These periods of high flows are also the periods of lowest salinity in Mobile Bay. Because in Mobile Bay the most important factor influencing salinities is the Mobile River, there is apparently a direct, though imprecise, relationship between high bacterial counts in Mobile Bay and high flow rates of the Mobile River. In effect, although other streams such as the Bon Secour, Deer, Fish, Fowl, and Dog Rivers are contributing to organic waste loads in Mobile Bay (Table 46), the Mobile River seems to be the primary source of bacterial pollution, except in highly localized areas (U.S. Army Corps of Engineers 1983).

Water use classification areas in Mobile Bay are shown on the atlas sheets. The areas delineated on the sheets indicate that water quality is lower in the northern and northeastern portions of the bay.

During periods of low dissolved oxygen, a phenomena known locally as "jubilees" may occasionally occur in Mobile Bay. During jubilees dermesal animals such as flounders and blue crabs are driven from the deeper parts of the bay to more shallow areas shoreward where they remain for several minutes or hours and provide a bountiful seafood harvest for those lucky enough to be in the area (Chermock 1974). The exact conditions causing jubilees are apparently quite complex, but they occur during the summer usually in the early morning. It should be noted that jubilees are naturally occurring phenomena, since the first recorded occurrence was in 1867, before any major human modifications to the bay occurred.

Perdido River Basin. Hollingers Creek (Bay Minette quadrangle), a tributary of the Perdido River, receives most of the city of Bay Minette's treated sewer wastes. Due to the low flows at some times of the year these wastes may make up over 90% of the stream's total flow. Low dissolved oxygen levels and high BOD (Table 46) are indicative of the poor water quality.

The Perdido River/Perdido Bay contribute large amounts of oxygen-demanding materials to the study area. This loading is primarily attributed to a single point source located at Cantonment, Florida. This same source also contributes to the esthetic degradation of the water by distributing unsightly foam and scum. The WFRPC (West Florida Regional Planning Commission) 208 reported that the Perdido River had depressed dissolved oxygen concentrations for more than 51% of the data reviewed. They also reported that both the Perdido River and Bay showed high nutrient values for a like percentage of the data considered (SARPC 1979).

Escatawpa River Basin. The Escatawpa River has very good-quality water. A reservoir on Big Creek (Mobile quadrangle), one of the Escatawpa tributaries, furnishes water for the city of Mobile. As indicated in Table

46, Escatawpa River water has average minimum DO levels of 6.0 mg/l and average maximum DO levels of greater than 12.0 mg/l. BOD levels are generally low. In general the reason for the good water quality of the Escatawpa River is the absence of large industries or population centers in the basin (SARPC 1979).

Coastal Drainages. Waters around Gulf Shores (Pensacola quadrangle) and Dauphin Island (Biloxi quadrangle) have water-quality problems (coliform bacteria levels) associated with improperly installed or defective septic tank drainfields. Bayou La Batre and Bayou Coden (Biloxi quadrangle) have poor water quality due to waste disposal from seafood industries operating in these areas (SARPC 1979).

GROUND WATER AVAILABILITY

The following discussion is taken primarily from Reed and McCain (1971 and 1972). There are good quantities of high-quality ground water available throughout Baldwin and Mobile Counties. Ground water in this area is available from permeable sands ranging in age from Eocene to Holocene. These formations can be placed in geologic perspective by referring to the generalized stratigraphic column in the Oil, Gas, and Minerals section of this atlas text. Tables 49 and 50 present data on the geologic series of relevant aquifers, their unit designation, their thickness in both meters and feet, yield, and comments on the general quality of water.

The principal aquifer in the area is the Miocene-Pliocene aquifer, comprising the Miocene Series and the Citronelle Formation, which is of Pliocene to early Pleistocene age. The structure of the aquifer is complex, the permeable beds of sand interfingering with relatively impermeable limestone and clay. The individual beds of permeable sand are usually 15 to 30 m (50 to 100 ft) thick, but reach a thickness of 58 m (190 ft) around Citronelle (Citronelle quadrangle) in Mobile County and 70 m (230 ft) in the vicinity of Loxley (Bay Minette quadrangle) in Baldwin County. The atlas sheets present the contours of the approximate depth (ft) below sea level of the base of the Miocene-Pliocene aquifer capable of yielding as much as 1 mgd per well.

Well depths to obtain small quantities of water from the Miocene-Pliocene aquifer range from 46 m (150 ft) deep in the northern portion of the study area to 30 m (100 ft) deep along the coast. These wells generally are capable of delivering at least 3.8 million liters of water per day (mld) (1 million gallons of water per day (mgd)). Wells pumping larger quantities of water range in depth from 29 to 244 m (94 to 800 ft) in depth. Water is pumped from these wells at 379 to 3,785 liters per minute (lpm) (100 to 1000 gallons per minute gpm)). The specific capacities of these wells are generally between 62 and 435 lpm per meter (5 and 35 gpm per ft) of drawdown. The atlas sheets present the contours of the approximate elevation (feet) above sea level to which water will rise in wells penetrating the Miocene-Pliocene aquifer.

The Eocene and Oligocene Series are a potential source of water in northeastern Baldwin County. This formation may produce 1.9 mld (0.5 mgd) per well in nearby Monroe County.

Table 49. Summary of geologic units, and availability and quality of ground water in Baldwin County (modified from O'Neil and Mettee 1982).

Series	Geologic unit	Thickness m (ft)	Availability of water	Quality of water
Holocene and Pleistocene	Alluvium low terrace, and coastal deposits	0-46 (0-150)	Will yield 38 lpm (10 gpm) where saturated sands are of sufficient thickness. Potential sources of 1,325 to 2,650 lpm (350 to 700 gpm) well in the Mobile basin.	Probably of good chemical quality in north half of county but locally may have a dissolved solids content that exceeds 1,000 mg/l and may contain objectional amounts of iron. In south half of county adjacent to major waterways, water commonly contains objectionable amounts of iron, is very hard, and has a sulfurous odor. Locally, in areas adjacent to the coastline, the water is highly mineralized.
	High-terrace deposits	0-9 (0-30)	Will yield 38 lpm (10 gpm) where saturated sands are of sufficient thickness.	Water probably is of good chemical quality; locally it may contain objectionable amounts of iron.
Pliocene	Citronelle Formation	0-40 (0-130)	Will yield 2,650 lpm (700 gpm) or more per well.	Water generally is of good quality being soft and low in dissolved solids. Locally, the water contains objectionable amounts of iron and generally is acidic. In some areas adjacent to the coastline and in the Mobile River basin the water has a dissolved-solids content that exceeds 1,000 mg/l, a chloride content that exceeds 500 mg/l, and a sulfurous odor.
Miocene	Miocene Series undifferentiated	30-900 (100-3,000)		
Oligocene		30-152 (100-500)		
	Eocene and Oligocene Series		Potential source of 1,325 lpm (350 gpm) per well.	Water may be of good chemical quality in northernmost part of the county near Little River. Dissolved-solids content exceeds 1,000 mg/l in all other parts of the county.
Eocene		120-210 (400-700)		

Wherever the permeable sand and gravel are of sufficient thickness, the alluvium and low terrace deposits of Holocene age are a potential source of groundwater along the Mobile River basin. These deposits may be as thick as 46 m (150 ft) and yield 1.9 to 3.8 mld (0.5 to 1.0 mgd) per well. Wells pumping large quantities of water from these deposits generally range from 27 to 45 m (89 to 148 ft) in depth, produce 1,779 to 3,202 lpm (470 to 846 gpm) and have specific capacities of 75 to 907 lpm per meter (6 to 73 gpm per foot) of drawdown.

Many industries in the Mobile area are supplied by wells in alluvial deposits. These wells reportedly produce 38 to 5,678 lpm (10 to 1,500 gpm) with specific capacities ranging from 75 to 807 lpm per meter (6 to 65 gpm per foot) of drawdown, production varying more upon the industries' needs rather than the ultimate well capacity.

Table 50. Summary of geologic units, and availability and quality of ground water in Mobile County (modified from O'Neil and Mettee 1982).

Series	Geologic unit	Thickness m (ft)	Availability of water	Quality of water
Holocene and Pleistocene	Alluvium, low terrace, and coastal deposits	0-46 (0-150)	Will yield 38 lpm (10 gpm) where saturated sands are of sufficient thickness. Potential sources of 1,325 to 2,650 lpm (350 to 700 gpm) well in the Mobile River	Water generally suitable for most uses but commonly contains iron in excess of 0.3 mg/l and may be sufficiently acidic to be corrosive. Locally, in areas close to Mobile Bay and Mississippi Sound, water is very hard, has high chloride and dissolved-solids contents, and contains iron in excess of 0.3 mg/l
	High-terrace deposits	0-12 (0-40)	Will yield 38 lpm (10 gpm) or more where saturated sands are of sufficient thickness	Probably soft and low in dissolved solids. May contain iron in excess of 0.3 mg/l.
Pliocene	Citronelle Formation	0-61 (0-200)	Will yield 2,650 lpm (700 gpm) or more per well.	Water generally is soft and low in dissolved solids but may contain iron in excess of 0.3 mg/l and may be sufficiently acidic to be corrosive. In areas adjacent to Mobile River, Mobile Bay, and Mississippi Sound, water may have a dissolved-solids content that exceeds 1,000 mg/l, a sulfurous odor, and a chloride content that exceeds 500 mg/l.
Miocene	Micocene Series undifferentiated	120-1,030 (400-3,400)		

GROUND WATER QUALITY

The following discussion is taken primarily from Reed and McCain (1971 and 1972). Most of the wells tapping the Miocene-Pliocene aquifer yield water that is good for most uses. The water is generally soft, with a dissolved solids content of only 250 mg/l. In localized areas, the water may be too acidic for some uses. Wells in areas near the major waterways may produce objectionable amounts of iron. Some wells on Dauphin Island (Biloxi quadrangle) produce water that is high in chloride and dissolved solids content and has a sulfurous odor. Recently, some wells in the vicinity of the Mobile (Mobile quadrangle) waterfront have shown an increase in chloride content, indicating an increase in saltwater encroachment. At Gulf Shores (Pensacola quadrangle) in Baldwin County, saltwater encroachment has also occurred.

The water produced from alluvium and low terrace deposits is similar to that from the Miocene-Pliocene aquifer in that it is mostly soft and is low in dissolved solids. It differs in that it frequently has iron in excess of 0.3 mg/l and is acidic enough to be corrosive. As these deposits are much shallower than the Miocene-Pliocene aquifer, they are more immediately

affected by the surface environment. For instance, alluvium deposits adjacent to Mobile Bay and Mississippi Sound may yield water that is very hard and high in iron, chloride, and dissolved solids.

Tables 51 and 52 display some of the important chemical characteristics of ground water produced from the wells in Baldwin and Mobile Counties. These wells are only representative, however, and only a very small portion of the wells in the study area are included on the atlas maps and in these tables. More detailed information is available from Reed and McCain (1971 and 1972).

CURRENTS

Factors affecting currents and circulation patterns along the Alabama coast include tides, freshwater discharges, shoreline configuration, winds,

Table 51. Chemical analyses of water from selected wells in Baldwin County (O'Neil and Mettee 1982, modified from Reed and McCain 1971).

No.[a]	Well Owner	Date of Collection	Well depth (ft)	Fe^{3+} (mg/l)	HCO_3 (mg/l)
Q-3	Bacon McMillian Veneer Co.	7-29-66	90	1.3	68
U-9	Town of Bay Minette	4-27-66	204	.05	6
CC-8	Spanish Fort Utility	4-27-66	341	2.2	34
KK-3	Town of Loxley	3-08-66	184	.07	6
LL-6	Town of Daphne	3-08-66	430	.10	13
MM-2	Grand Bay Development Corp.	5-12-66	338	.26	88
NN-3	Town of Fairhope	3-15-66	510	.96	46
PP-1	Town of Robertsdale	3-11-66	203	.06	3
SS-9	Baldwin Co. Bd. of Educ.	6-16-66	80	.78	6
UU-6	Riviera Utilities	3-14-66	157	.10	0
WW-1	Fairhope Hatchery	6-24-66	70	.27	4
XX-4	H. B. Bentley	6-24-66	155	1.1	10
YY-9	Bon Secour Fisheries	8-05-66	220	---	4
AAA-8	S. A. Braham	7-13-66	22	.33	4
BBB-8	C. W. Bear	6-16-66	197	.66	6
CCC-1	Gulf Telephone Co.	7-12-66	40	1.3	6
CCC-9	W. G. and P. Gilcrist	7-11-66	750	.17	618
DDD-17	State of Alabama	7-01-66	44	.50	66
EEE-7	B. Terry	6-29-66	17	.34	2
GGG-4	W. M. Apple	6-29-66	15	.08	136
HHH-4	U. S. Coast Guard	7-28-66	31	.26	228

[a] Well numbers correspond to those on atlas maps.

longshore currents and the Coriolis effect which, due to the earth's rotation, tends to deflect currents to the right (clockwise) (Chermock 1974).

Tidal currents in Alabama estuaries are of the reversing or rectilinear type. The flood current flows into the estuaries for about 6 h and the ebb current flows out for about 6 h. Between these two phases there is a slack period when the currents generate no movement. The strengths of these currents varies with the moon's angle of declination (Chermock 1974). Fresh water discharges from streams flowing into Alabama estuaries influence the tidal flows by increasing the ebb current and decreasing the flood current in proportion to the stream discharge. Shoreline configurations deflect or funnel current flows according to the flow direction. Since shoreline configurations are constantly changing (on a geological time scale), current patterns also tend to change. Water levels and currents can be influenced by winds according to their velocity, direction, and duration. For example, strong south winds tend to pile water at the head of Mobile Bay, while north winds decrease the water level.

Table 51. (concluded)

	Hardness as $CaCO_3$ (mg/l)			
Cl (mg/l)	Ca^{++} Mg^{++}	Noncar-bonate	Specific conductance (μmhos at 25 °C)	pH
4.4	22	0	123	7.5
4.4	12	7	25	5.4
6.0	15	0	90	6.6
4.0	10	5	21	5.6
5.2	15	4	46	6.4
3.0	30	0	155	7.5
4.2	32	0	98	6.8
8.6	15	13	42	5.5
5.4	15	10	44	6.1
15	28	28	103	4.5
8.4	20	17	53	6.6
6.6	8	0	35	6.8
4.8	8	5	38	5.4
6.0	5	2	37	5.3
4.6	15	10	36	5.6
14	8	3	63	5.8
2,500	160	0	8,190	7.8
52	65	11	277	7.1
9.8	12	10	54	5.6
320	188	76	1,260	7.3
27	202	15	432	7.8

Longshore currents in the Gulf of Mexico tend to move from east to west at rates of 1 to 3 mph and tend to deflect outgoing tides to the west. On incoming tides these currents increase to 3 to 6 mph (Chermock 1974). Man-made factors such as ship channels, spoil lands, and causeways tend to alter natural current patterns.

Table 52. Chemical analyses of water from selected wells in Mobile County (O'Neil and Mettee 1982, modified from Reed and McCain 1971).

Number[a]	Well Owner	Date of collection	Water-bearing unit[b]	Well depth (ft)	Iron (Fe) (mg/l)
G-1	Water and Sewer Board, Citronelle	6-27-67	Tpm	805	0.49
J-6	Alabama Power Co., Barry Steam Plant	8-11-67	Qal	135	0.24
K-1	Stauffer Chemical Co. (LaMoyne Plant)	8-16-67	Qal	128	0.08
S-7	Town of Saraland	7-26-67	Qal	98	0.27
AA-1	U. S. Coast Guard	7-23-67	Tmp	198	0.16
CC-1	Scott Paper Co.	9-13-67	Qal	90	1.9
CC-10	U. S. Post Office	7-18-66	Tpm	739	0.52
EE-5	U. S. Government, Brookley Air Force Base	8-15-67	Qal	113	8.3
II-4	Grand Bay Water Works Bd.	6-21-67	Tpm	155	0.24
KK-2	Mobile Co. Water and Fire Protection Authority	6-26-67	Tpm	476	0.30
LL-2	McWane Cast Steel Pipe Co.	7-11-66	Tpm	120	0.68
MM-2	Bayley's Ranch Club	8-14-67	Qal	90	0.12
NN-3	Bellingrath Gardens	7-28-67	Tpm	308	0.56
RR-1	Roman Catholic Church, Brothers of the Sacred Heart	9-06-67	Tpm	566	1.6
SS-1	J. L. Regan, Jr.	8-30-67	Tpm	109	0.36
TT-2	C. B. Sprinkle	7-28-67	Tpm	400	0.16
UU-5	Isle Dauphin Country Club	6-28-67	Qal	38	2.0
UU-6	Dauphin Island Property Owners' Association	6-28-67	Tpm	563	1.3

a Well numbers correspond to those on atlas maps.
b Water-bearing unit: Qal, alluvium, low-terrace, and coastal deposits; Tpm, Pliocene-Miocene Series undifferentiated.

Perdido Bay

Currents in the upper portion of Perdido Bay (Pensacola quadrangle) have been studied by the U.S. Army Corps of Engineers (Federal Water Pollution Control Administration 1970). These studies show that during ebb tides, both surface and bottom currents flow out to sea. During flood tides, the surface currents, which are made up of freshwater discharge, still flow out to sea, but the bottom currents are more complicated. Bottom currents, probably

Table 52. (concluded)

Bicarbonate HCO_3 (mg/l)	Carbonate CO_3 (mg/l)	Chloride Cl (mg/l)	Hardness as $CaCO_3$ (mg/l): Calcium, magnesium	Hardness as $CaCO_3$ (mg/l): Noncarbonate	Specific conductance (μmhos at 25 °C)	pH
135	0	12	2	0	255	8.2
26	0	6.8	2	0	59	6.6
----	0	2.4	5	0	27	6.5
15	0	7.0	8	0	52	6.1
6	0	2.6	4	0	18	6.0
22	0	926	390	372	3,100	6.2
460	0	1,560	85	0	5,290	8.2
40	0	28	29	0	159	6.6
6	0	4.4	4	0	28	5.7
156	11	51	12	0	479	8.8
8	0	8.2	8	1	52	5.9
16	0	6.2	11	0	69	6.8
56	0	9.2	8	0	138	7.2
96	0	80	15	0	375	7.2
92	0	16	1	0	196	7.3
144	0	80	5	0	467	8.0
92	0	110	113	38	536	8.1
128	0	650	123	18	2,320	7.1

consisting of a wedge of salt water, move upstream in Perdido Bay during a flood tide. These upstream currents encounter the usual downstream currents and create counterclockwise bottom currents in the upper basin of Perdido Bay. Figures 18 and 19 show flood- and ebb-tide current patterns in Perdido Bay.

The velocities of flood tides in Perdido Bay have been measured by the U.S. Army Corps of Engineers to average 0.8 m/s (2.5 ft/s) and reach a maxium of 1.2 m/s (4.0 ft/s). Ebb-tide velocities average 0.6 m/s (2.0 ft/s) and reach a maximum of 0.7 m/s (2.3 ft/s).

Mobile Bay and Mississippi Sound

Information on current patterns in Mobile Bay has been collected by several researchers, using both field observations and computer modeling. Austin (1954) was the first to map flood and ebb tide circulation patterns in Mobile Bay. Story, et al. (1974) traced circulation patterns in a portion of Mobile Bay by the use of fluorescent dye markers. Several publications by Schroeder (1976, 1977, 1979a, 1979b) discuss circulation patterns in Mobile Bay. His studies involved current data collected while anchored, drogue studies, and inferring circulation patterns from salinity patterns.

Computer models of Mobile Bay have been developed by April et al. (1976), April and Raney (1979), Pitts and Farmer (1976), and Gaume et al. (1978). The major difference between these models is how they model the openings of the bay, which are complicated by Dauphin and Little Dauphin Islands (Biloxi quadrangle) (O'Neil and Mettee 1982). Figures 20 and 21 show flood and ebb tide current patterns in Mobile Bay as predicted by April et al. (1976).

The general circulation pattern in Mississippi Sound is induced by the tides but wind has a significant effect on the currents. Horn Island Pass (Biloxi quadrangle) is the natural dividing point for tidal currents in the Mississippi Sound. During flood tide the currents bifurcate in the Horn Island Pass area and flow westward and eastward. From Horn Island pass to Mobile Bay, currents flow in through the passes and eastward on the flood tide, then westward and out during ebb-tide (U.S. Army Corps of Engineers 1983).

Recent numerical modeling by the U.S. Corps of Engineers (1983) on current patterns in Mobile Bay and Mississippi Sound indicate that wind has a significant effect on circulation patterns. East and west winds have a pronounced effect with north and south winds having minimal effects. Variance in wind velocities also exerted pronounced effects on circulation patterns (U.S. Corps of Engineers 1983).

The effect of the wind on the tidal currents is mainly to superimpose a wind induced current on the Sound that shifts the bifurcation of the currents either toward the east or west. The eastward or westward movement of the current depends upon the direction of the wind and whether the tide is in ebb or flood. An east wind component induces a westward current in the Sound, which causes a shift in the current dividing point to the east during flood-tide and to the west on the ebb-tide. Winds with a component from the west

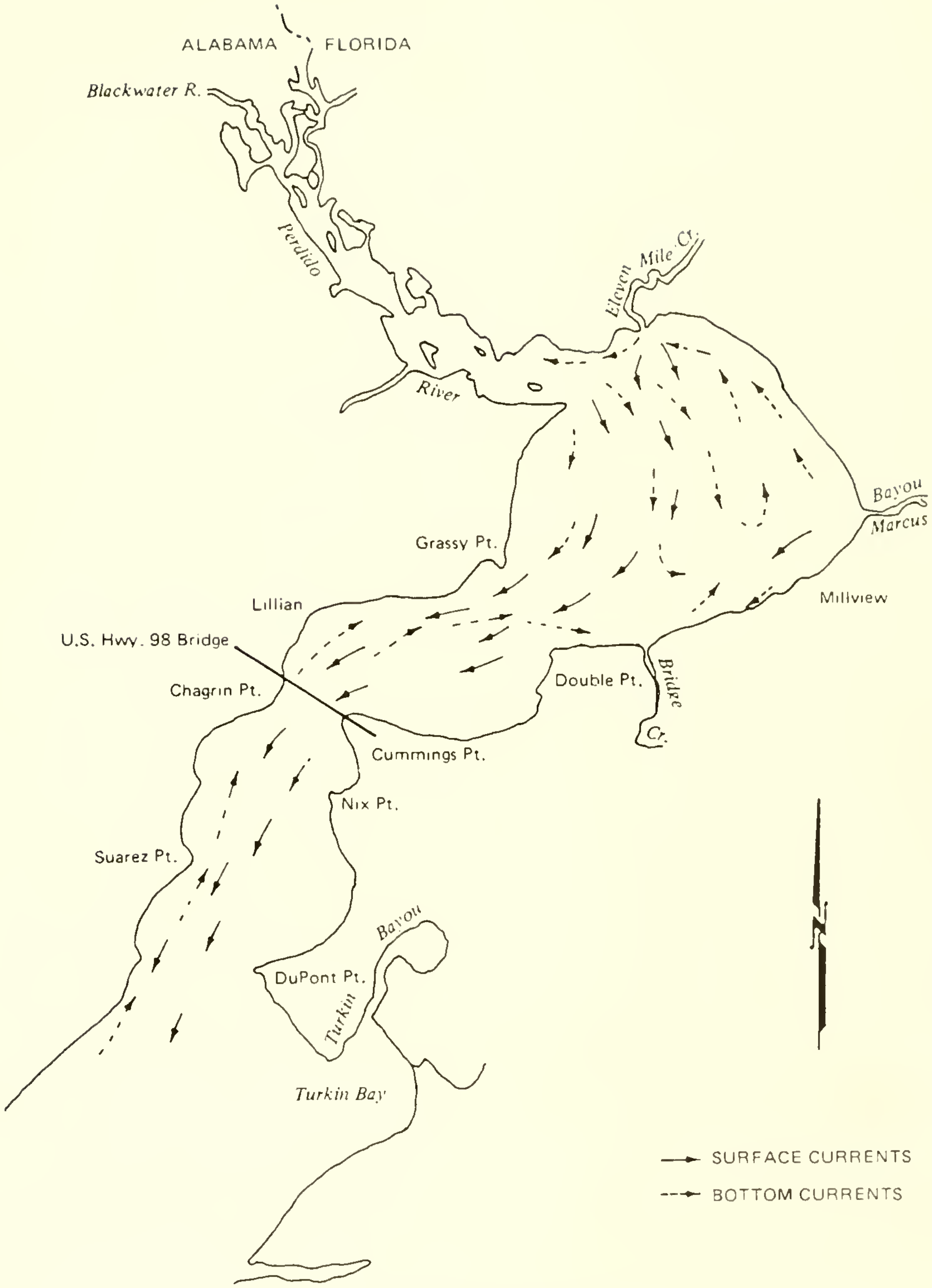

Figure 18. Flood-tide current patterns in Perdido Bay (Federal Water Pollution Control Administration 1970).

Figure 19. Ebb-tide current patterns in Perdido Bay (Federal Water Pollution Control Administration 1970).

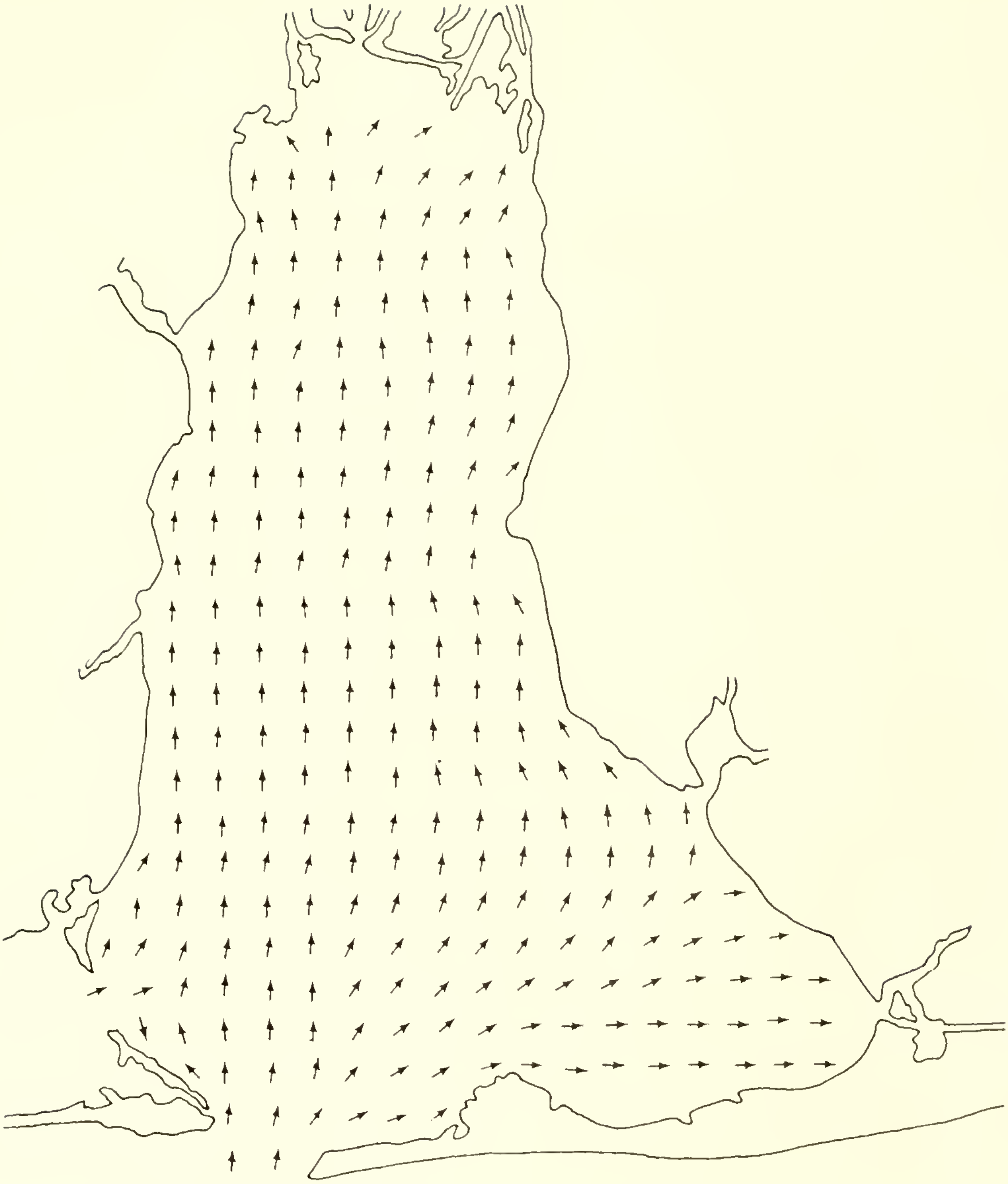

Figure 20. Velocity directions for flood-tide flow predicted by a hydrodynamic model, Mobile Bay (April et al. 1976).

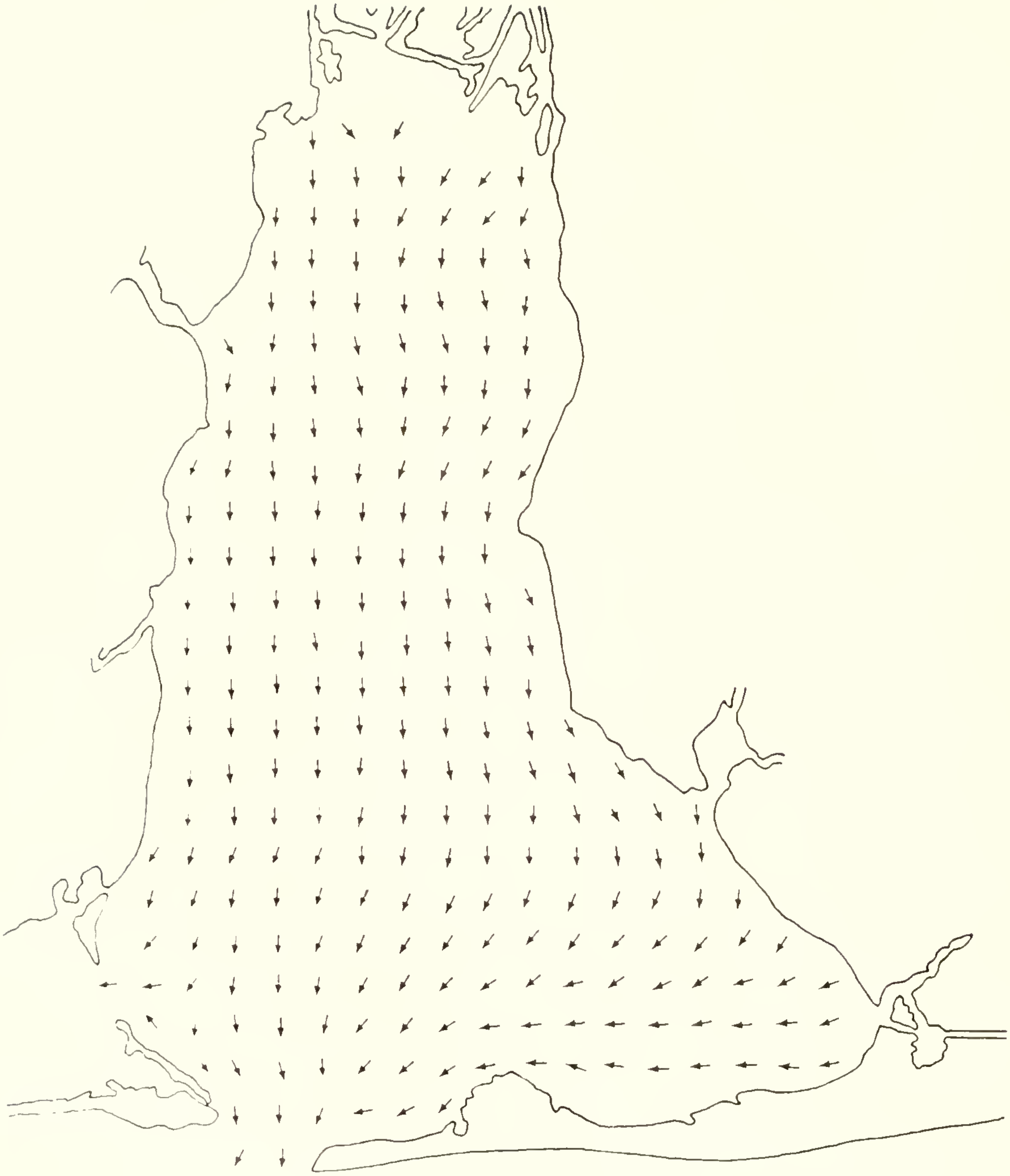

Figure 21. Velocity directions for ebb-tide flow predicted by a hydrodynamic model, Mobile Bay (April et al. 1976).

superimpose a general eastward current in the Sound. The wind-induced eastward current forces the currents to bifurcate further west on the flood-tide and further eastward on the ebb-tide (U.S. Army Corps of Engineers 1983).

Tidal elevations are also influenced by the wind. An east wind tends to lower elevations in the eastern part of the sound and increase tidal elevations in the western part of the Sound. A west wind has the reverse effect of increasing elevations in the east and lowering elevations in the west. (U.S. Army Corps of Engineers 1983).

Tidal current velocities in Mobile Bay average between 0.15 and 0.76 m/s (0.5 and 2.5 ft/s) (O'Neil and Mettee 1982) Velocities in Mississippi Sound vary from 0 to .24 m/s (.8 fps). In general, peak velocities throughout the Mississippi Sound will increase by 40% per one foot increase in the tidal range (U.S. Corps Army of Engineers 1983).

SALINITIES

The salinity regime of Mobile Bay can vary from 0 to 34 to 36 parts per thousand (ppt). Individual locations within the bay may vary a great deal due to interactive factors such as tidal regime, currents, river discharge, rainfall, and velocity and direction of the wind. In deeper portions of the bay vertical stratification (layering) may also occur.

The most important factor influencing salinity in Mobile Bay is the discharge of the Mobile River. During seasonal high-flow periods (February through April), surface salinities are often less than 10 ppt in most of the bay. During the low-flow period from July through December, surface salinities increase, reaching 10 ppt in the northern portions of the bay and 20 ppt or more in the southern portions (U.S. Army Corps of Engineers 1983). The seasonal surface salinities in Mobile Bay are mapped on the atlas sheets and show these extremes.

Higher salinities are found more in bottom water than in surface water. This is especially true in the Mobile Ship Channel (Mobile quadrangle) which allows the denser saltwater to extend as far as 23 mi up the Mobile River. Stratification in Mobile Bay is most often present during the low-flow periods of the Mobile River, and less pronounced during the river's high-flow periods. Mixing of the waters in the bay appears to be retarded by the spoil banks on either side of the ship channel, since they act as submerged partitions (O'Neil and Mettee 1982).

Perdido Bay shows many of the same characteristics as Mobile Bay except that saltwater wedge intrusion is less pronounced and mixing is greater in the lower part of the bay, reducing stratification (O'Neil and Mettee 1982).

The Mississippi Sound (Biloxi quadrangle) has the highest salinities of the three estuaries, reflecting the free connection with gulf water and small inflow of fresh water. In addition, stratification is minor, with the difference between surface and bottom salinity being only 2 ppt (Bault 1972).

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This 28-page document gives detailed daily weather data and figures describing the weather over the calendar year 1979 on Dauphin Island.

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U.S. Army Corps of Engineers. 1981a. Hurricane Frederic post disaster report 30 August-14 September, 1979. Mobile, AL.

Discusses all aspects of the results of Hurricane Frederic. Contains meteorological and hydrological data as well as many photos of the area. 61 plates of aerial photos and beach profiles are appended to the report.

Water Quality and Stream Discharge

Reed, P. C. and J. F. McCain. 1971. Water availability map of Baldwin County, Alabama. Geol. Surv. Ala. Map 96.

A 55-page narrative containing both water quality and quantity data complete with illustrations and tables. The map shows discharges and well data at a scale of approximately 1 inch = 2 mi.

Reed, P. C., and J. F. McCain. 1972. Water availability map of Mobile County, Alabama. Geol. Surv. Ala. Map 121.

A 45-page narrative containing both water quality and quantity data complete with illustrations and tables. The map shows discharges and well data at a scale of approximately 1 inch = 2 mi.

South Alabama Regional Planning Commission. 1979. Water quality management plan, Mobile and Baldwin Counties Alabama. South Ala. Reg. Plan. Comm. Mobile.

Large document prepared as partial requirement of Public Law 92-500, the Federal Water Pollution Control Act Amendments of 1972, Section 208. Contains water quality assessments, standard, needs and projections. Basic water planning document for coastal counties of Alabama.

U.S. Army Corps of Engineers. 1981b. Environmental data inventory, State of Alabama. Mobile. 325 pp.

Atlas contains 1:250,000 colored maps for entire state dealing with physiographic, biological, and cultural events. These maps include information on aquifers, surface water, flood prone areas, etc.

U.S. Geological Survey. 1981. Water resources data for Alabama, water year 1980. Vols. I and II: Apalachicola, Choctawhatcee, Blackwater,

Escambia, Perdido River Basins, and Alabama River in the Mobile River Basin. U. S. Geol. Surv. Water Res. Div. University.

Contains records of stage, discharge, and water quality of streams, stage and contents of lakes and reservoirs, and water levels in wells.

U.S. Geological Survey Hydrologic Units

U. S. Geological Survey. 1974. Hydrologic unit map-1974. State of Alabama. U.S. Geologic Survey, Water Resources Division, University..

A map of the hydrologic units of Alabama, with county codes, and hydrologic regions, subregions, accounting and cataloging units, and explanations.

Water Use Classifications

South Alabama Regional Planning Commission. 1979. Water quality management plan, Mobile and Baldwin Counties, Alabama. South Ala. Reg. Plan. Comm. Mobile.

Large document prepared as partial requirements of Public Law 92-500, the Federal Water Pollution Control Act Amendments of 1972, Section 208. Contains water quality assessments, standard, needs and projections. Basic water planning document for coastal counties of Alabama.

Groundwater and the Miocene-Pliocene Aquifer

Reed, P. C. and J. F. McCain. 1971. Water availability map of Baldwin County, Alabama. Geol. Surv. Ala. Map 96.

A 55-page narrative containing both water quality and quantity data complete with illustrations and tables. The map shows discharges and well data at a scale of approximately 1 inch = 2 mi.

Reed, P. C. and J. F. McCain. 1971. Water availability map of Mobile County, Alabama. Geol. Surv. Ala. Map 121.

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U. S. Army Corps of Engineers. 1981b. Environmental data inventory, State of Alabama. Mobile. 325 pp.

Atlas contains 1:250,000 colored maps for entire state, dealing with physiographic, biological, and cultural events. These maps include information on aquifers, surface water, flood-prone areas, etc.

Walter, G. R. 1976. The Miocene-Pliocene aquifer and the alluvial aquifer. in H. C. Barksdale, et al., eds. Water content and potential yield of significant aquifers in Alabama. Geol. Surv. Ala. Open File Rep.

Information on the location, thickness, extent and structure of the major aquifers of coastal Alabama. Contains detailed data on water quality and capacities of the aquifers.

Salinities

Bault, E. I. 1972. Hydrology of Alabama estuarine areas--cooperative Gulf of Mexico Estuarine Inventory. Ala. Mar. Res. Bull. 7. 36 pp.

Contains bimonthly surface and bottom isohaline maps (in parts per 1000) of Mobile Bay and Mississippi Sound.

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15. Supplementary Notes

*Minerals Management Service Report No. MMS 84-0052

16. Abstract (Limit: 200 words)

This report is a descriptive explanation of data presented on 30 maps (maps not available from NTIS) produced at a scale of 1:100,000 for the coastal Alabama Region - Mobile and Baldwin Counties. Topics mapped include biological resources; socioeconomic features; soils; oil, gas, and mineral resources; and hydrology and climatology.

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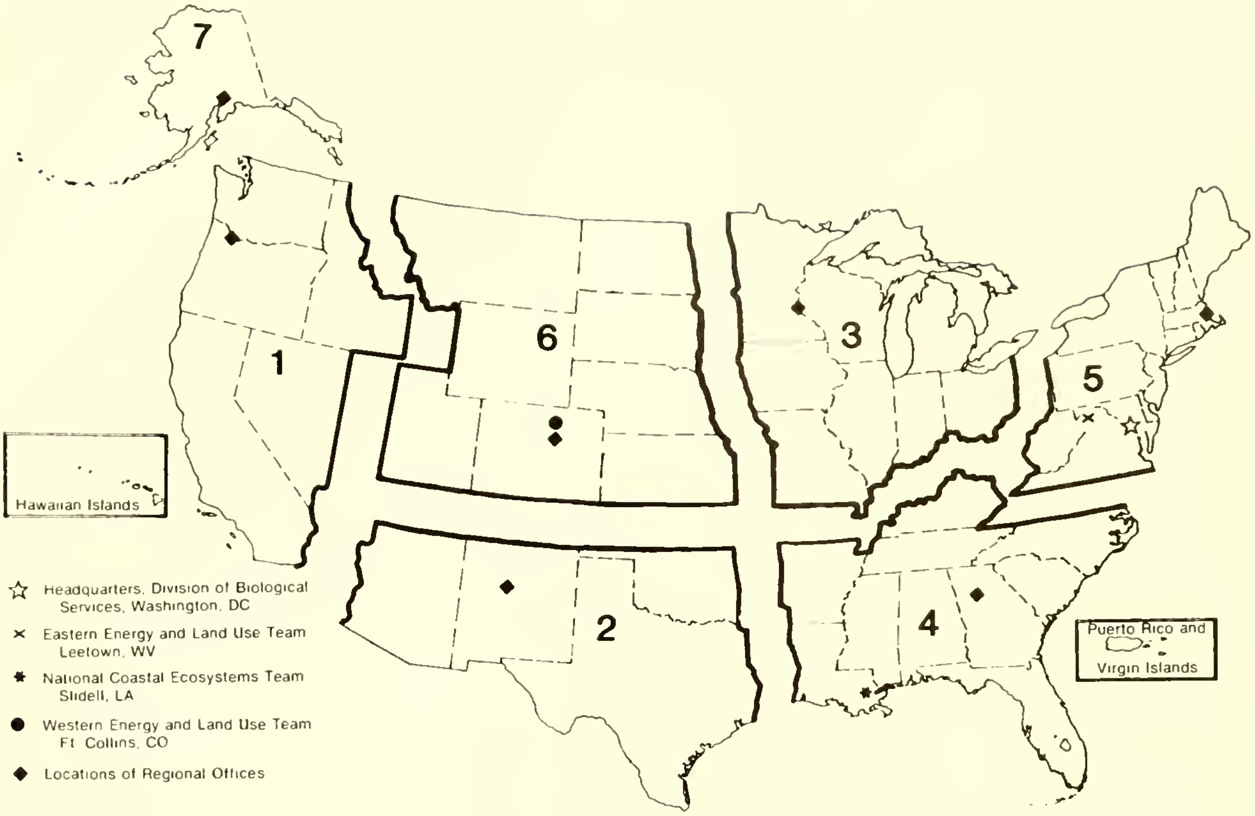

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